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THE ENGINEERS' DIGEST

REVIEW OF ENGINEERING PROGRESS ABROAD

PRINCIPAL CONTENTS

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The Influence of Mach Number upon the Airscrew Efficiency

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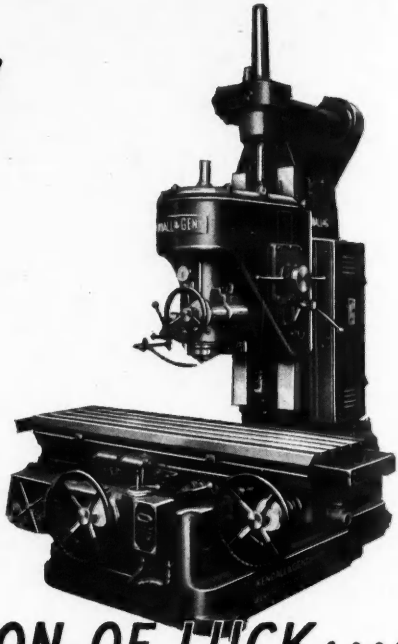
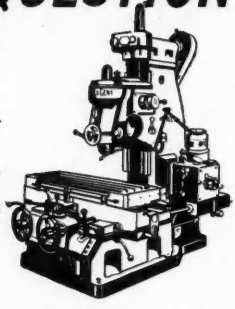
Progress



IT'S NOT A QUESTION OF LUCK.....



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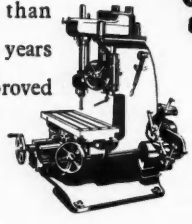

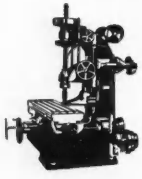

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EDITORIAL

It is no need to emphasise the far-reaching effects of the war upon our peacetime production, and our design engineers are well aware of the necessity of supplementing, improving, or replacing certain vital material requirements. This war is generally called a war of machines, or, with other words, an engineer's war. The engineer's knowledge, intelligence, and energy is, however, far from being fully utilized in the production itself, and in an even lesser degree in the economic direction of the production. Every engineer could support this statement with a great number of facts.

During the last decade, most excellent progress has been made in the manufacture of Plastics, and there are to-day, literally, thousands of synthetic materials of construction available to the design engineer.

In spite of this fact, the amount of synthetic materials used in this country is little compared with the consumption of Plastics in Germany, or in the United States. We consider it of the utmost importance to the national effort that critical materials should be replaced wherever possible with materials which can be produced from raw material we have in abundance.

It is beyond the scope of THE ENGINEERS' DIGEST, *which deals with engineering progress abroad, to give account of the great amount of research work being done in the research laboratories and factories of our Plastics industry. Yet we hope to promote the interest for application of plastic materials by publishing in future issues of the* DIGEST *articles on successful application of Plastics in foreign countries.*

ECONOMIC DESIGN FOR MAGNESIUM ALLOY CONSTRUCTION

By DIPL. ING. MAX SCHONBERG. (From *ATZ, Automobiltechnische Zeitschrift*, Vol. 44, No. 12, 25th June, 1941, pp. 295-305).

THE need for utmost economy in the use of raw materials calls for a full utilisation of the working material. In this respect, the designer is greatly assisted by making use of light metals and their alloys, but at the same time, it must be borne in mind that with new light alloys new principles of design are introduced.

Whereas formerly strength consideration was almost the sole factor influencing the design,

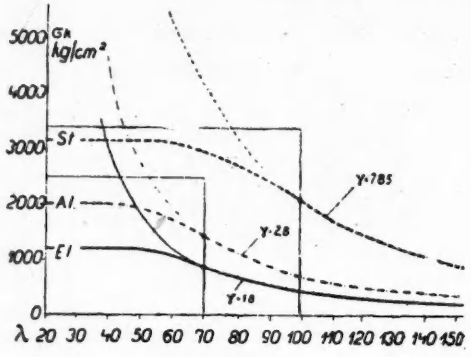


Fig. 1

with the light alloys, emphasis is shifted to the elastic modulus of the material, because with sections reduced to a minimum the problem is not only that of sufficient strength, but also of adequate fatigue strength. Although the standardised strength figures of the light alloys form the basis of the calculation of design, these have to be reduced in practice since they refer only to static conditions of loading. Further considerations should be given to the actual working temperatures, wear and abrasion resistance, friction and surface characteristics, corrosion resistance and local overstressing.

Comparison of Electron with Iron.

The inferior strength of electron compared with iron and steel can only be compensated by an enlargement of the cross-sectional area of the stressed member. This principle holds for all manner of stresses, e.g., pure tension or compression, bending or shearing. Owing to the much larger strength/sp. weight ratio of electron and other light alloys, the practical saving in weight of structure is considerable. When buckling occurs, electron compares more favourably with steel in the Tetmayer region than in the Euler zone. In this respect, an improvement can be obtained, apart from increasing the cross-sectional area, by using a prop. Fig. 1 gives the Euler curves for steel, aluminium, and electron (note: sp. wt. of electron is 1.8). Fig. 2 shows the percentage saving in material when electron is used in place of steel in girders resisting forces.

Holes for rivets or bolts weaken the material, and in this case the remedy is to use larger cross-sections. The effect of these holes is similar to that of sharp bends causing local overstressing to which electron is particularly sensitive. Fig. 3 gives some data of sheet thickness to be used for various rivet diameters.

Although from the foregoing the usefulness of electron as working material in a great variety of

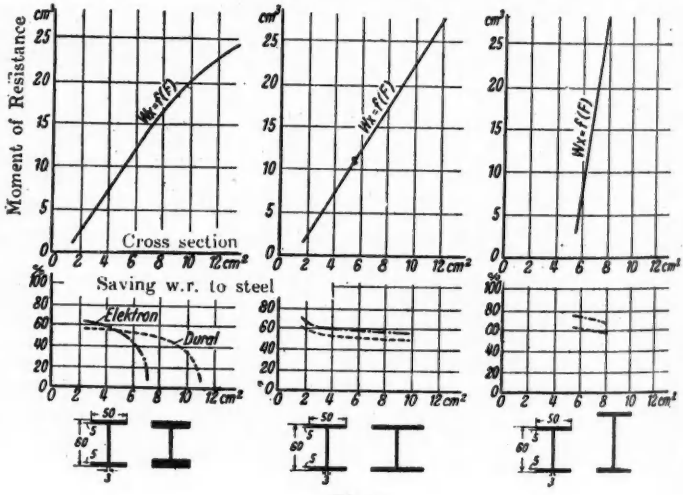
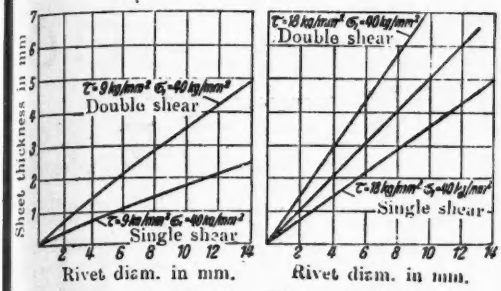


Fig. 2


Sheet thickness in mm
τ = 9 kg/mm² σc = 40 kg/mm²
Double shear
τ = 9 kg/mm² σc = 40 kg/mm²
Single shear
Rivet diam. in mm.
τ = 18 kg/mm² σc = 40 kg/mm²
Double shear
τ = 18 kg/mm² σc = 40 kg/mm²
Single shear
Rivet diam. in mm.

Rivet material = Pure Al. Rivet material = Hy. 5.

Fig. 3.

applications should be quite clear, there are certain limitations to its use, arising partly from economical considerations (electron is rather expensive) and partly from design problems, as for example in the case when an enlargement of a section cannot be permitted.

Castings made from magnesium alloys find a wide application in the motor car industry. Not only is it possible to prepare castings of dimensions and wall thicknesses which from heavy metals would not be feasible because of weight considerations, but because of the increased possibilities of cast machine parts, the cost of series production is reduced. Sand, chilled, and spray castings are equally suitable. Various types of electron castings and their physical properties are tabulated in Table I.

Fabricating the article by casting is especially suitable for electron; almost ideal flow lines in the casting can be obtained. This fact contributes to economy, as it allows a maximum utilisation of the material by reducing the dimensions everywhere to a minimum. Moreover, the small value of E for electron (2860 tons per sq. in.) allows a large deformation of the material before fracture. As an example, an electron wheel used on a mobile gunisshown in Fig. 4, which has stood up excellently to the stresses and shocks throughout several years' service.

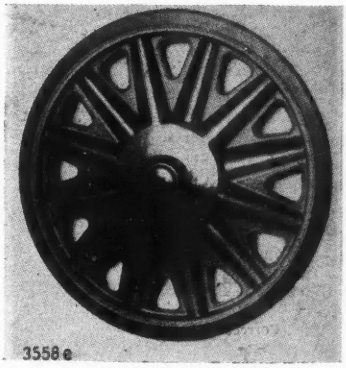


Fig. 4

Table I.

SAND CASTINGS.

Alloy	Colour	Specification	Elastic limit 0.02% kg/mm²	Strain limit 0.2% kg/mm²	Tensile strength kg/mm²	Elong. at fracture %	E kg/mm²	Reduct'n of area at fracture %	Compr. stn'gth kg/mm²	Brinell hardness kg/mm²	Shear stn'gth kg/mm²	Endurance bending stn'gth kg/mm²	Applications
AZG	yellow-white	GMg-Al 6-Zn	4-5	9-11	16-20	3-6	4300	4-7	33	58	13	7-9	For stressed machine parts, e.g., aero engine covers.
AZF	yellow-green	GMg-Al 4-Zn	3-4	7-9	17-21	5-9	4200	7-11	32	50	13	6.5	For castings exposed to shock stresses.
A 9 V	yellow-blue-black	GMg-Al	4.5-5.5	10-13	24-28	8-12	4400	8-15	33	62	14	8-12	High shock or heat stress resistance, heat treatment needed.
AM 503	yellow-red	GMg-Mn	2	3	9-11	3-6	—	5-9	17	35	9	—	Corrosion resistant castings. Easy welding, use: lightly loaded parts.
CHILLED CASTINGS.													
AZ 91	yellow-blue-red	GMg-Al	5	11-13	18-22	2.5-5	4400	4	33	62	13	8-9	Normal chilled castings.
A 8	yellow-blue-green	GMg-Al	4	9-10.5	20-24	5-10	4300	7-12	33	55	13	7-8	High shock stress resistance. For castings of simple form.
SPRAYED CASTING.													
AZ 91	yellow-blue-red	SpGMg-Al 9	6	15	18-20	1-2	4300	4	—	65	—	—	For sprayed castings of all descriptions.

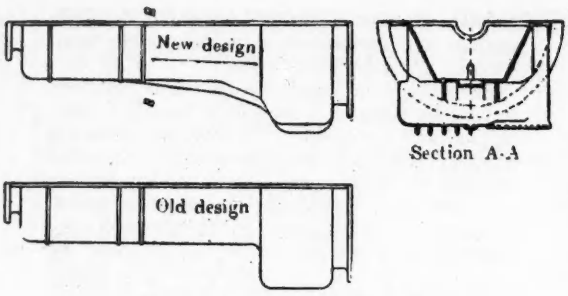


Fig. 5. Crank case of a bus motor.

The corner effect is prominently marked for electron and other types of light alloys. Therefore, the work has to be designed with small stresses along the edges (see Fig. 5). This consideration gives rise to some modification in the design and is shown in Figs. 6 and 7. As a rule, sharp corners must be avoided.

Fig. 6

The use of collars is recommended wherever high tensile stresses may be present at the periphery of the section. This applies also to the circumference of holes and to H sections as shown in Figs. 7 and 8. On the other hand, accumulation of material should be avoided if possible, otherwise internal stresses may be produced owing to differential cooling. At points where the load is applied this cannot be prevented, as these parts have to be massively designed. From

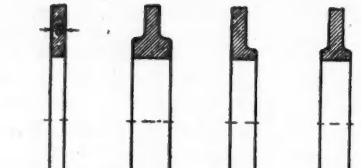


Fig. 7

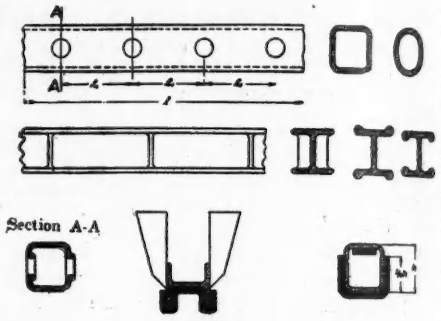


Fig. 8

these points the stress should be uniformly transmitted to thinner sections by providing an adequate number of ribs or webs. All transitions from heavier to lighter sections should be gradual as shown in Fig. 9. As a protection against corrosion all parts should be designed without pockets or recesses so that the water can flow away freely.

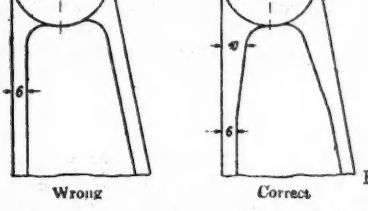


Fig. 9

Bearing and supporting surfaces carrying heavy stresses should be reinforced with heavy metals. Overdimensioning of these parts is dangerous, because of warping which might occur during cooling.

The usual method of fastening light alloys is by bolting. It is sound practice to use a greater number of bolts of small diameter in place of a smaller number of bolts of larger diameter. Thread cutting in electron is only allowable if there is sufficient thickness of metal surrounding the hole; the threads should be cut clean and properly relief ground. For milling operation a rounded hob should be used.

Pressed and forged electron alloy machine parts form an important group in industrial application. Table II. gives the mechanical properties of such alloys, and their superiority is apparent. They offer a better surface and require less finishing; stress distribution also becomes more uniform. Forging of electron alloys makes it possible to

Table II.

Alloy	Colour	Specification	Elastic limit 0.02% kg/mm²	Strain limit 0.2% kg/mm²	Tensile strength kg/mm²	Elong. at fracture %	E kg/mm²	Reduct'n of area at fracture %	Compr. stn'gth kg/mm²	Brinell hardness kg/mm²	Shear stn'gth kg/mm²	Endurance bending stn'gth kg/mm²	Applications
AZM	yellow-white-yellow	Mg-Al 6	17-19	20-22	28-32	10-16	4500	15-30	38	60	15	14-17	Mainly for rods, profiles and tubes.
AZ 855	yellow-blue-black	Mg-Al 9	18-20	21-23	30-33	8-12	4500	10-25	39	65	15	14-17	For rods and highly stressed forged parts.
AM 503	yellow-red	Mg-Mn	8-10	16-20	22-30	1.5-5	4200	2-5	33	42	13	7.5	For rods, profiles and tubes. Corrosion resistant and easy to weld.

construct machine parts in one piece, which formerly had to be fabricated in two or more parts, and in this way further saving of material is achieved. But here also it must be remembered that close collaboration between designer and forging expert must exist to satisfy both the requirements of construction and of forging technique.

Most elaborate profiles can easily be obtained by pressing. Another important feature of pressed parts is that they can be bent. This is best performed at about 250 to 300° C.

Some general rules should be followed when welding (Fig. 10). A special welding flux is used from which the work must be cleaned after welding, as it contains chlorides which attack the base metal. Drawing and joining of electron is possible without difficulty.

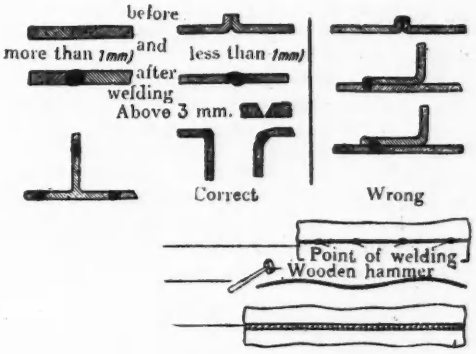


Fig. 10

THE BEHAVIOUR OF LAMINATED SYNTHETIC PRESSED RESINS IN CREEP

By H. PERKUHN. (From *Luftfahrtforschung*, Vol. 18, No. 1, 1941, pp. 32-37).

THE creep of synthetic resins used in aircraft is already at room temperature as high as that of metallic materials at elevated and high temperatures, which however, are never encountered under normal operational conditions.

Owing to the structure of synthetic resins, which is neither homogenous nor isotropic, the problem of creep presents considerable difficulty. Investigations published up to now were limited in range. The present experiments indicate new methods to improve the creep characteristics. The testing apparatus used is shown in Fig. 1. The loading of the test rods by weights (1) is accomplished by a lever arrangement (2) of the ratio 1:6. The compensating weights (3) and (4) enable rough as well as exact adjustment. To ensure centric loading the test rods are fixed in adjustable spherical heads (5). Sudden loading is avoided by springs (6) and the adjustable slap (7). The elongation was measured by a "Fuess Kathetometer," exact to $\pm$ 0.01 mm. The relative humidity of the air was kept constant (70%), and a thermostat employed to keep the air temperature at 20 $\pm$ 1° C. The test rods (Fig. 2) had an overall length of 170 mm., of which 60 mm. constituted the working sectors. The thickness of the rods was approximately 1.2 mm.

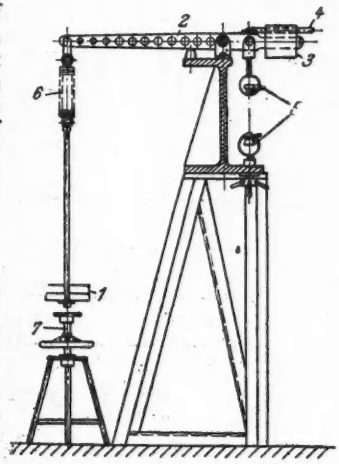


Fig. 1

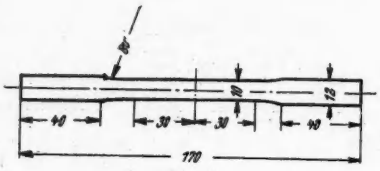


Fig. 2

The resins used in these tests were of the phenol-formaldehyde type, the laminations consisting of (A) Cellulose (paper), (B) Cotton tissue.

The phenol-formaldehyde resin was between 9% and 51% of the weight of the finished product. The pressing was carried out at 145° C, whereby the pressures were 60, 200 and 600 kg/cm².

The following strength characteristics were determined:

(1) Static strength in relation to
  (a) Compression pressure
  (b) Content of synthetic resin.

Under "static strength" the maximum stress is understood to be that which can be supported for at least 30 days without fracture.

(2) Strains corresponding to the stresses under (1). Strains were measured during a period of 185 hours of loading, and again 185 hours after unloading.

(3) Endurance static strength (Creep strength).

The creep under load was measured after 185, 500 and 700 hours, and after unloading and resting the permanent elongation was noted.

Fig. 3 shows the static strength of cellulose-laminated resin (D.V.L.) with various resin contents, Fig. 4 that of cotton tissue laminated resins. The static strength (stress) varies between 50% and 75% of the ultimate tensile strength. After two days' loading the average strength is 40% lower than in a tensile test at a rate of loading of 800 kg/cm²/min.

Fig. 5 shows the increase in static strength with increasing compression pressure during manufacture. No appreciable increase in static strength is noted by exceeding a compression pressure of about 250 kg/cm² (1.5 tons/sq. in.).

The static strength in relation to the resin contents is shown in Fig. 6 for (a) cotton tissue laminated resins (D.V.L.); (b) cellulose-laminated resin (D.V.L.).

The highest strength values are obtained with between 30% and 40% of resin content, a further increase in resin results in decreasing strength.

Strains at stresses corresponding to the static strength are shown in Fig. 7. All materials have exceeded the strain which is generally permissible in structural technics. Already after 190 hours'

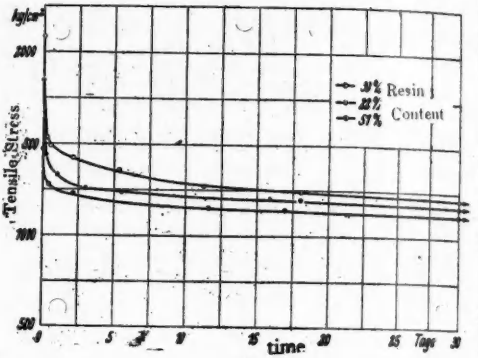
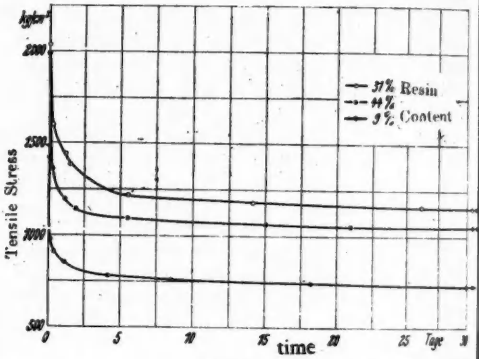


Fig. 3 Tage=days



Compr. Pressure Tage=days
Fig. 4

loading the permanent stretch exceeded 0.2%. It is also clear from Fig. 7 that with increasing time the rate of extension decreases without reaching zero. The question emerging here is whether

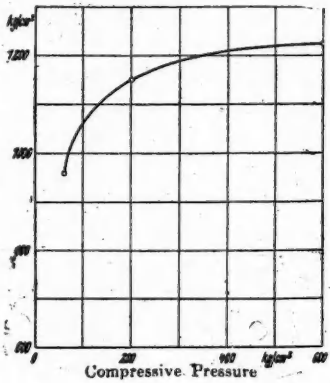


Fig. 5

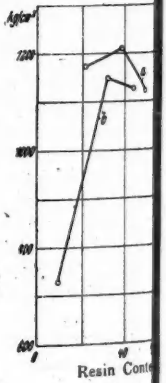


Fig. 6

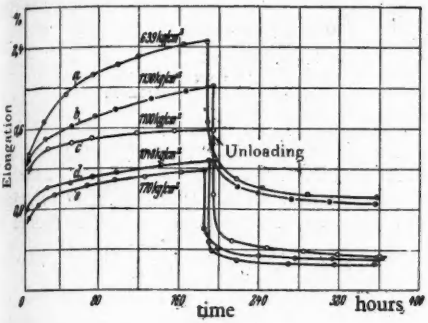


Fig. 7

in finite time there is a danger of fracture. To settle this is important as the definition of creep strength (or endurance static strength) requires the knowledge at any time of the rate of elongation. To this end the author shows a series of curves which represent a slight refinement of the method of F. Gentner published in "Archiv für das Eisenhüttenwesen" (No. 9, 1936, pp. 441-450, Die Auswertung von Dauerstandversuchen).

In conclusion the author arrives at the definition of creep strength as that stress which will produce a rate of extension of $5 \times 10^{-4}\%$ per hour between the 100th and 110th hour of loading. After unloading and resting for 24 hours, the permanent stretch of the material must not exceed 2%. The table below contains the creep strength of three different cellulose-laminated resins:

Material	Tensile Strength kg/cm²	Creep Strength according to rate of extension $5 \times 10^{-4}\%$ in the 100th hour of loading, in kg/cm²	Creep Strength in % of tensile strength
D.V.L.	2038	715	30.1
Z 3A	2175	600	27.6
Commercially available	1310	290	22.2

DETERMINATION OF THE CO-EFFICIENT OF THERMAL CONDUCTIVITY OF PLASTIC MATERIALS

By WE. KOCH. (From *Kunststoffe*, Vol. 31, No. 4, April, 1941, pp. 135-137).

THE necessity of determining the co-efficient of thermal conductivity of plastic materials is emphasised by the fact that the VDI (Association of German Engineers) intends to standardise an instrument for such measurements. The author of this article suggests the following method and apparatus.

If a constant quantity of heat is permitted to flow through a plate (base plate) of known surface area (f) m², thickness (s_g) m. and coeff. of thermal conductivity λ_g, than the value of λ_x of a second plate can be calculated from the temperature measurements at both sides of the two plates. If t_w, t_m and t_m, t_k are the temperatures at the two sides of the base plate, and the plate under investigation respectively than

$$q = \frac{\lambda_g}{s_g} f \,.\, (t_w - t_m)$$

and for the second plate

$$q = \frac{\lambda_x}{s_x} f \,.\, (t_m - t_k),$$

and hence,

$$\lambda_x = s_x \frac{\lambda_g}{s_g} \cdot \frac{t_w - t_m}{t_m - t_k} \text{ /Kcal/m.h.°C/.}$$

The apparatus is shown in Fig. 1. A Turbonite disc (a) (cardboard) is placed between two aluminium plates (b and c), and fastened together by two bolts. Between the plates a

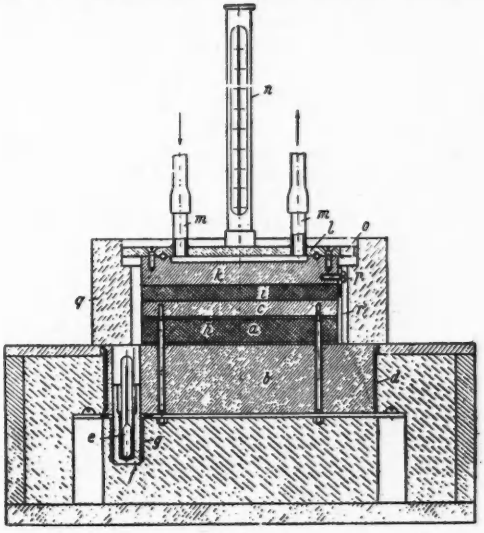


Fig. 1

thin layer of rubber is introduced so that the plastic disc adheres to the discs (b) and (c). The disc (b) carries a heating wiring of 1600 ohm resistance connected to a 220 volt main. The temperature of (b) is kept constant at 48° C. by means of a mercury valve control (e). The latter is placed inside an aluminium tube (f), which is also provided with heating coils (g) of 600 ohm resistance.

For the temperature measurements thermo-couples are used, embedded into the two rubber layers (h) and insulated from the neighbouring aluminium discs by a thin Micanite plate. The disc under investigation (i) carries on its upper side a cooling plate (k), which has a recess on the upper surface. (k) is covered with yet another plate (l) of larger diameter through which two nozzles lead to the recess in (k) for the circulating cooling water. Finally (n) is a mercury thermometer to measure the temperature t_k of the plate (k).

The use of aluminium parts throughout the construction is due to the relatively high thermal conductivity of aluminium compared with that of plastic materials. In fact it is many thousand times as high, and therefore the temperature drop across the aluminium plates can be safely neglected.

For measurements on elastic materials, three strips of sheet metals (r) are used, fastened in position by the nuts (p). The use of these sheet strips does not influence the results appreciably. For further heat insulation the upper part of the apparatus is surrounded by a cork ring (q).

Calibration of the Apparatus.

Since direct determination of the ratio $u = \lambda_g/s_g$ would not take account of the effect of the rubber layers, aluminium discs and thermo-elements, the equivalent value of u has to be determined by calibration. The following method is recommended:

For a plate of known λ and thicknesses put in place of disc (i), we have

$$\frac{\lambda_g}{s_g} = u = \frac{\lambda}{s} \cdot \frac{t_m - t_k}{t_w - t_m}$$

The temperatures t_w, t_m, t_k are identical with the temperatures of the discs (b), (c) and (k), and are measured by the thermo-couples. Further, since within the range of the working temperatures the electrical energy is proportional to the temperatures, the ratio $\frac{t_w - t_m}{\alpha}$ can also be established, where α is the deflection of the millivolt-meter. Finally a small correction has to be made on the reading of the mercury thermometer (n).

From the calibration of the experimental model by four plastic materials, all of known thickness and thermal conductivity, the mean values for u, v, and W were found to be 21.51, 0.2140, and -0.1 respectively. Substituting these values into the equation

$$\lambda_x = s_x \frac{\lambda_g}{s_g} \cdot \frac{t_w - t_m}{t_m - t_k}$$

we get after simplifying,

$$\lambda_x = \frac{4.603 \alpha s_x}{49.6 - 0.2247\alpha - t_k}$$

The accuracy of this method is illustrated in Table I., where values of λ for four materials, determined from the calibration, are given together with the directly measured absolute values.

TABLE I.

Material	λ	λ_x	$\frac{\lambda_x - \lambda}{\lambda} \cdot 100$
Mycalex (1)	0.565	0.567	+0.4
Mycalex (2)	0.596	0.599	+0.5
Turbonite	0.251	0.251	0
MPSO	0.140	0.138	—1.4

NEW DEW-POINT MEASURING INSTRUMENTS AS MEANS OF GREATER FUEL ECONOMY IN DRYING PLANTS

By E. KOBEL. (From *Schweizer Archiv*, Vol. 7, No. 4, April, 1941, pp. 112-114).

THE two dew-point measuring instruments described below are both of very simple construction and operation, and can be used alternatively to suit conditions.

The first type is illustrated in Fig. 1. It consists essentially of a cylindrical copper container with a highly polished chromium outside surface. Hot water is circulated in the container so that its temperature can be varied between 10 and 100° C. The hot water supply is from a "Cowa" type of hot water regulator in the illustrated instrument. A light beam is

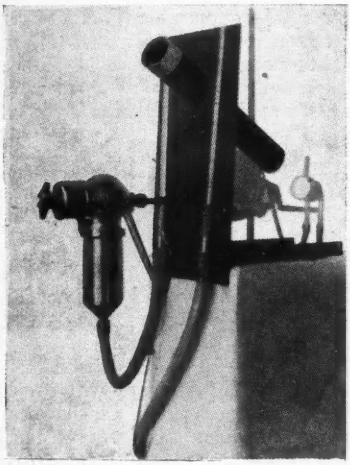


Fig. 1

reflected from the polished surface and the efficiency of reflection is about 80-97% if the temperature of the container lies above dew-point, and only about 50% or less if it lies below that.

Observation of the reflection is by direct observation or by means of a photo-cell. To remove dust particles from both the polished surface and the observation window a rubber wiper may be used. The dew-point is determined by slowly reducing the temperature of the container by means of the hot water regulator, until a sharp change in the intensity of reflection occurs. At this point readings are taken on the thermometers fitted to the hot water inlet and return pipes respectively. Fig. 2 shows the relation between relative humidity and dew-point for various air temperatures.

For applications where a light beam cannot be used the following instrument can be adopted. A hollow cylindrical " body " of non-conducting material, such as glass, is heated in a similar manner as before. To the outside of the body two electrodes are fixed, taking the shape of coil springs. The electrical connection to the electrodes should be well protected from heat. If now the temperature of the non-conducting body falls below the dew-point, the condensed vapour will form a conducting coating, closing the electric circuit. This is used to light an electric bulb or operate a bell. At this stage readings are taken again on the thermometers.

The amount of fuel saving in a plant if sufficient consideration is given to relative humidity and dew-point conditions, is illustrated by the following example.

Volume of air	$V = 1\ m^3$
Barom. pressure	$h = 730$ mm. HG.
Air temperature	$t_L = 98°$ C.
Dew-point	$t_d = 45°$ C.

The relative humidity is in this case $\rho = 0.1$. The quantity of steam carried away in 1 m^3 of air is $x = 0.0545$ kg. The sp. weight of air at $\rho = 0.1$ is 0.825 kg/m^3, and that of dry air is 0.912 kg/m^3. Hence the heat content is 0.271 cal/kg or 0.224 cal/m^3.

If now the air circulation is regulated so that the dew-point is increased to 55° C., then for $t_L = 98°$ C., the relative humidity becomes $\rho = 0.16$. The steam carried away per m^3 of air is 0.119 kg. Thus only 0.46 kg of hot air is required to deal with the same amount of steam as before. The heat content of the air is now 0.295 cal/kg and the total saving in heat is 40%.

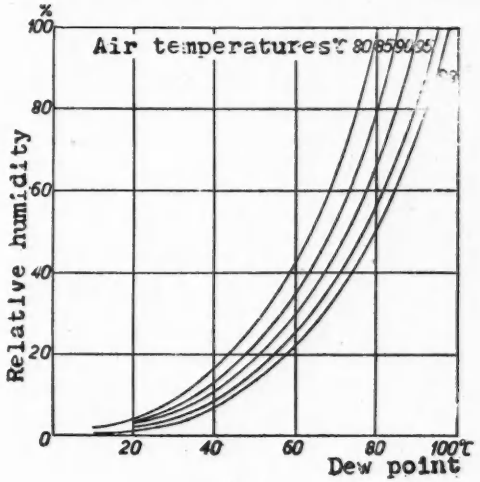


Fig. 2

THE INFLUENCE of MACH NUMBER UPON THE AIRSCREW EFFICIENCY

By H. Wolff. (From *Luftfahrtforcshung*, Vol. 18, 1941, pp. 67-69. Report of the Focke-Wulf Aircraft Co., Bremen).

With the increase in flight speed (v), a growing difficulty is being experienced in the design of airscrews. The task of maintaining high airscrew efficiency is getting more difficult with the increase in engine power per airscrew (N) which is to be transformed into thrust (S).

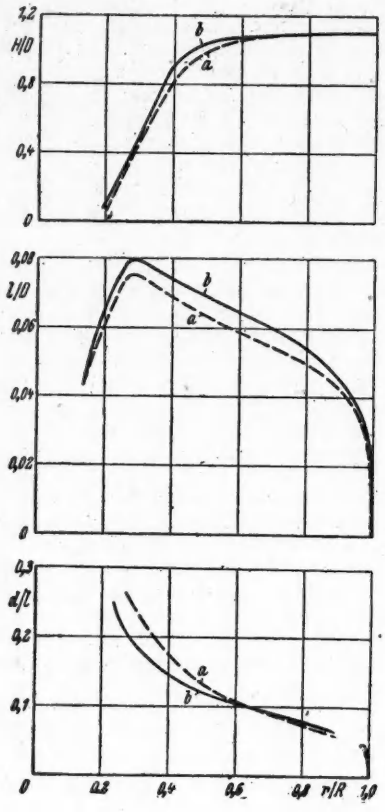


Fig. 1

Blade ratios of $\frac{\text{pitch}}{\text{diameter}}$, $\frac{\text{width}}{\text{diameter}}$ and $\frac{\text{thickness}}{\text{width}}$ for two Focke-Wulf airscrews : (a) D=2.90 m. ; M=0.96 ; (b) D=2.95 m. ; M=0.973.

Power absorption by an airscrew can be increased by increasing the diameter (D), the speed, or by both means simultaneously. Either of these methods result in increase of tip speed (u) of the blade, the upper limit of which is the velocity of sound.

The ratio $\frac{\text{tip speed}}{\text{velocity of sound}}$ is known as the Mach number, M. Dependent on k_s=thrust coefficient= $\frac{S}{\rho/2\, u^2\, F}$, and the thickness of blade profile (d), a distinct loss of efficiency is observed already at Mach numbers below M=1.0 (ρ= density of air, F=blade area).

Flight tests were carried out on the FW 200 A, the Focke-Wulf "Condor" with two airscrews, the characteristics of which are shown in Fig. 1, whereby the advance ratio v/u was maintained constant. By noting the apparent increase in drag of aircraft with airscrew r.p.m., Fig. 2 was obtained. This apparent increase in drag is actually due to a reduction in the efficiency of the airscrew caused by the high tip speed, i.e., a consequence of the influence of the Mach number on airscrew efficiency.

In the present investigation the definitions and nomenclature are the same as used in Weinig's paper, "Airscrews for High Speed Aircraft." (Luftfahrtforschung, Vol. 14, 1937, pp. 168-172), which claims that the efficiency η_u can be determined, which is a function of Mach number and average lift coefficient $\bar{C}_a$ of the blade only. To obtain the effect of high tip speeds on the known efficiency of the airscrew this has to be multiplied by η_u.

The lift function is defined by :—

$$\bar{C}_a = \frac{\pi \cdot k_s}{\frac{2}{3} z \cdot \frac{l_m}{D}}$$

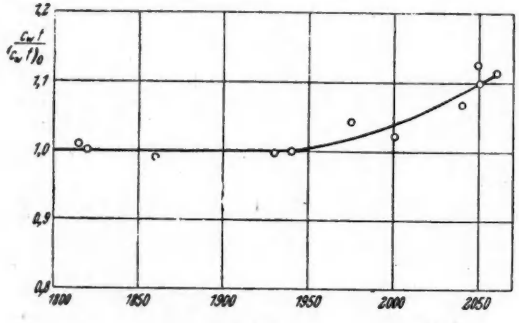


Fig. 2 r.p.m.

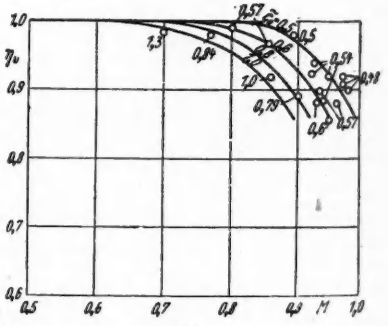


Fig. 3

where z=number of blades,

$$\frac{l_m}{D} = \frac{\text{mean chord}}{\text{diameter of blade}} = 4\int_0^1 \frac{l}{D}\left(\frac{r}{R}\right)^3 \cdot d\left(\frac{r}{R}\right)$$

S=Thrust, F_p=Disc area, u=Tip speed, z=Number of blades, l=Blade chord, l_m=Mean chord.

The result of the FW 200 flight tests is summarised in Fig. 3. The values obtained for η_u are in good agreement with tests of the N.A.C.A. (Technichal Report 639) which were evaluated for the same relations. The effect of high $\overline{C}_a$ and Mach number on η_u is greater than obtained by Weinig from theoretical considerations. No compressibility effect, however, could be deduced from flight tests at Mach numbers below about M=0.65.

The result obtained can be stated generally, i.e., valid for all airscrews provided the profile is suited for high speed work. Thus thin sections with maximum thickness at 40% chord and beyond should be used, and the pitch distribution should be very near to constant in the region of the blade tip. With such airscrews also the blade width must be greater than is usual to-day. The greater blade width would give a decrease in efficiency for cruising which can be improved by giving full throttle instead of throttling down. As an added advantage an improvement in the specific fuel consumption of the engine will result.

AERODROME AND AIRCRAFT LIGHTING

By W. T. HARDING and A. D. DIRCKSEN. (From *Electrical Engineering*, Vol. 60, No. 4, April, 1941, pp. 157-162).

Aerodrome Lighting.

Aerodrome lighting resolves itself into two major engineering problems. Of first importance is that of proper light distribution which is the concern of an illuminating engineer. The second problem is that of equipment and of electrical distribution.

Equipment.

Beacon.—The standard Air Corps beacon

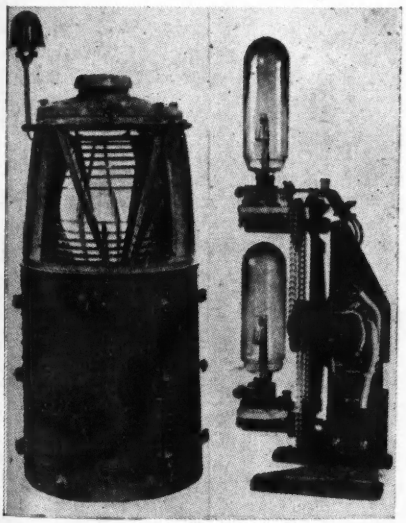


Fig. 1

(Fig. 1) consists briefly of a Fresnal lens optic, in which the lamp is moved periodically along the axis of symmetry. The result is a radial beam of light that sweeps up and down through a vertical angle from 2 to 18 degrees above the horizontal. When viewed by a distant pilot the beacon appears to flash normally 80 times a minute. The principal advantages over the older rotating types are:

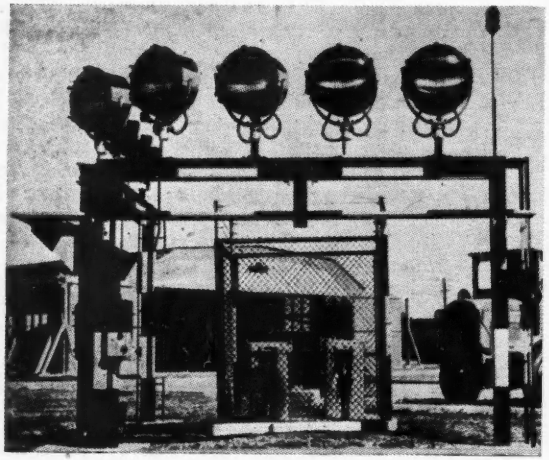
(1) The beacon flashes 80 times/min., as compared with the 6 flashes produced by a rotating beacon.

(2) The signal within limits is independent of altitude, which allows a pilot to approach a field at a constant altitude.

Outline lights.—The usable landing area generally is outlined by a system of obstacle and boundary lights. The former mark dangerous obstacles which must be avoided, and the latter denote the limits of the landing area. For fields having hard-surfaced runways, the use of boundary lights is problematical and they may be eliminated ultimately.

Floodlights.—These can be classified into two general types:

(1) One type covers a fairly large area upon which landings can be made in any direction. In general, for fields at which the wind conditions require approaches from all directions, three or four banks equally placed around the landing area, each with selective control and each covering a sector not exceeding 90 degrees, has been found most acceptable arrangement (Fig. 2).



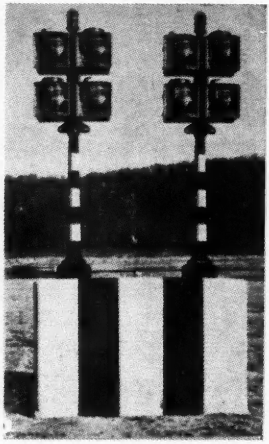


Fig. 2

(2) The second type of floodlights is applicable to fields with hard-surfaced runways, at which it is desirable to restrict the floodlighting to the runway surfaces. The bridge type with drum floodlights (Fig. 2) can best be utilized for this purpose. The standard practice of the Air Corps at present is to place such an installation at the approach end of the runway approximately 300 feet to the right and to utilize four spread lenses. An 80-degree lens is used to cover the runway closest to the floodlights, then 30-degree, 10-degree, and plain lenses to cover successive portions.

There is a tendency at present toward the elimination of floodlights at fields with hard-surfaced runway and adequate runway contact lights. Many pilots prefer to land without floodlights, depending upon aircraft landing lights if additional lighting is necessary. The latter, however, is unnecessary for a trained pilot if the ground contact lights are adequate.

Runway or Contact Lights. As indicated, contact lights, if adequate, form a major part of an aerodrome lighting system. These lights are placed along hard-surfaced runways at regular spacings and have a specialized distribution which concentrates the light signal in the angles along which a pilot normally approaches for a landing. These lights (Fig. 3) are essentially marker lights denoting the position of the runway surface.

Approach Lights.—Under adverse weather conditions during which aircraft may be guided toward the approach to the landing runway by radio aids, it is generally recognised to be extremely desirable to complete the landing operation by observing ground lights in lieu of making a complete blind landing. It is the intent of the developments under way to have the approach lights serve as the first ground aid which, in turn, will lead into the contact light system which will be used for completion of the landing manœuvre.

Electrical Circuits.

Series circuits are used for outline-light, contact-light, and approach-light systems. With these circuits, series multiple transformers are used for the following reasons:

(1) In case of collision, the high voltage series circuits are usually undisturbed.

(2) Obstacle lights may be installed upon buildings without danger due to high voltage.

(3) Magnetic coupling between the series circuit and lamp reduces the possibility of short circuiting a circuit or part thereof if water grounds one or more lights.

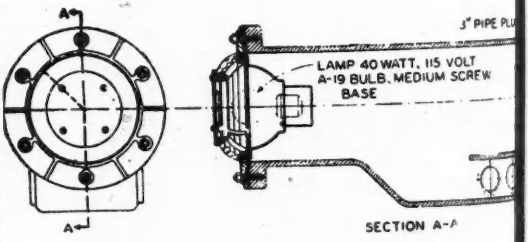


Fig. 3

A typical installation of a subway type of series multiple transformer in the base of a contact light is shown by Fig. 4. For floodlights it has been the practice to supply a 2300 volt primary feeder from centre of distribution to floodlight. At the floodlight a 2300/32 volt transformer with taps to compensate for line drop is used. Controls of the various circuits are centralized in a control tower.

Emergency Power.

The utility of an adequate aerodrome lighting system is dependent upon a constant source of electrical energy. The Air Corps has developed therefore, an automatically operated equipment to supply power in an emergency. As the first step in this development action has been taken to provide distribution systems operating at either 2300 volt delta or 400 volt star. Two items of standardised equipment as follows were then developed, which could be connected at will for either voltage.

(1) Primary Cubicle. This equipment consists of a self contained hand or automatically operated switching device. When set for automatic operation it is designed to transfer the load from the preferred source to the emergency source in event of failure of one or more phases of the preferred source. The primary cubicle includes metering from the preferred source, instruments for determining the electrical load from either source, and overload protection from either source.

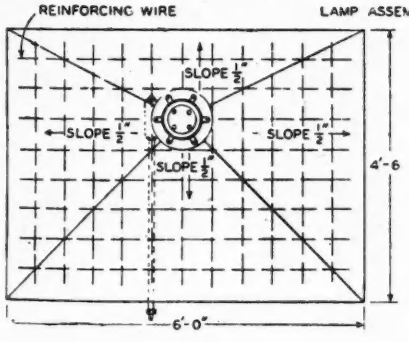
(2) Emergency Cubicle. This includes a battery charger, a voltage regulator and a control panel. The latter consists of the necessary relays to start the power plant from a 12 volt battery source in event the 230 volt pilot circuit from the primary cubicle is de-energised and to provide automatic shut down when power is resumed.

Aircraft Lighting.

Landing Lights.—The present standard electric retractable type landing lamp assembly is mounted in the lower surface of the airfoil. Experimental tests are being conducted on sealed beam lamps for aircraft landing lamps. The use of these lamps would permit increased wattage and light output and eliminate reflector maintenance.

Position Lights (Wing and Tail).—The Air Corps recently has standardised on the single unit type position light. The change from the two unit wing type lights previously used to the single unit wing tip light was due to less aerodynamic drag of the one lamp unit. This reduction in aerodynamic drag is increasingly important with the present and future type airplanes due to increasing speed and performance.

Formation Lights.—These are used by the Air Corps to permit formation flying of tactical airplanes and to permit the extinguishing of the airplane wing tip and tail lights. The formation lights are located on top of the fuselage and wing surface to eliminate observance of the airplanes by ground personel. The formation lamp circuit is controlled by a dimming rheostat with an incorporated "off" switch. The formation lamps assembly uses a blue lens to reduce the visibility



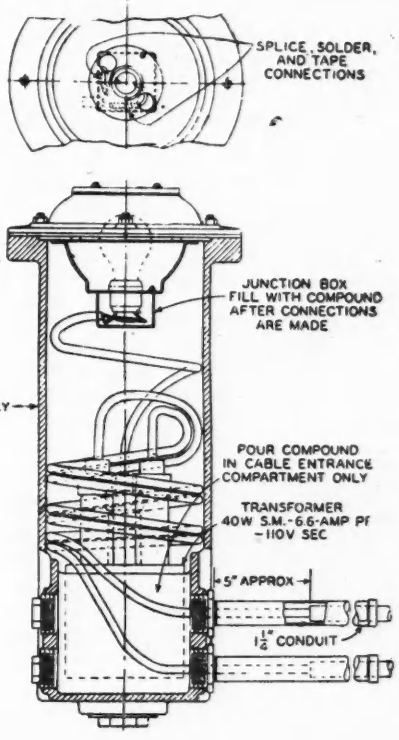

LAMP ASSEMBLY
SPLICE, SOLDER, AND TAPE CONNECTIONS
JUNCTION BOX FILL WITH COMPOUND AFTER CONNECTIONS ARE MADE
POUR COMPOUND IN CABLE ENTRANCE COMPARTMENT ONLY
TRANSFORMER 40W S.M.-6.6-AMP PF -110V SEC
5" APPROX
1 1/4" CONDUIT

Fig. 4

of the light signal to be seen by the trailing airplanes of a formation flight.

Cabin Lights.—A new type of dome light was standardised by the Air Corps which uses a 21 candlepower silver tipped light shielded lamp. This lamp assembly is used in the airplane where no gasoline vapour will be present. In locations where gasoline vapour may be present a vapour tight dome light will be used. This vapour tight lamp assembly uses an impact resisting cover glass and is suitably gasketed to render the unit vapour tight.

Indicator Lamps.—These are used throughout the airplane for indicating fuel pressure, oil pressure, radio marker beam, camera operation, bomb release, etc. A box is used for housing the signal lamps provided with plastic light transmitting nameplates. A test switch provided in this box permits checking of the lamps prior to and during flight.

Bomb release Signal Lamp Assembly.—A bomb release signal light is used to permit formation bombing. It consists of two 100 candlepower lamps in reflectors and is located to project the light beam to the rear for signals to the trailing airplanes. One lamp and reflector giving a white signal is used to indicate the opening of the bomb-bay door. The other lamp with reflector is provided with a red cover glass which indicates the time of release of the bomb. A time-delay relay is used to give the red light signal a duration of approximately 3 secs.

Inter Aircraft Control Lamp Assemblies.—Inter aircraft control lights are used for communications between airplanes in formation in the event that the use of radio communication is not permissible. The assembly recently standardized is of magnetically operated shutter type which intercepts the light between the lamp and reflector. The lamp assembly is hand operated.

Instrument Lighting. — Fluorescent instrument lighting has been adopted by the Air Corps recently. This type of lighting employs the method of floodlighting the instrument panel with near ultraviolet light to increase the activation of the luminous material and to activate the fluorescent identification, range makers and intermediate scale divisions. It is necessary that the lamp assembly be installed between the pilot and the instrument panel and so arranged as to floodlight the instruments uniformly.

THE PROGRESSIVELY ACTING FUSE

By A. GANTENBEIN. (From *Bulletin of the Association Suisse des Electriciens*, Vol. 32, No. 9, May, 1941, pp. 189-196).

SURVEY of the main types of fuses used up to the present.

The original fuse: The bare wire in air.

If a heavy current is sent through a wire stretched in open air, the wire first glows then it starts to melt at single points (Fig. 1). The glowing beads of metal are cast away from the melting points until distinct interruption occurs. No excessive voltages are produced with this type of fuse. Fig. 2 shows the fusing of a 0.2 mm. diameter silver wire, produced when a large current is passed through it. The metal beads are blown away along the whole length of the wire.

If the current is increased further, all fusible material vaporizes suddenly, without producing metal beads before vaporizing (Fig. 3). As the metal vapours at vaporizing temperature (for silver 2000-2100° C.) are practically non-conducting a very sudden increase of the resistance

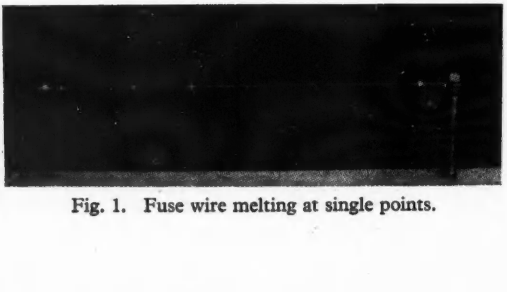


Fig. 1. Fuse wire melting at single points.

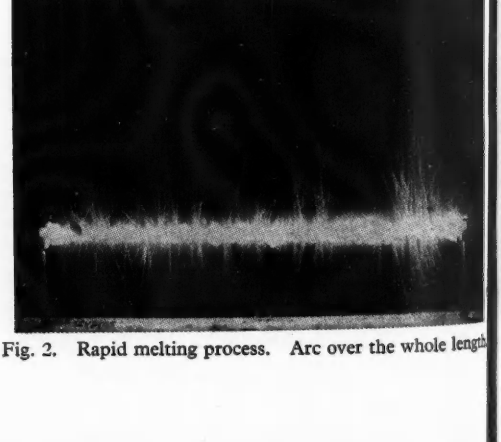


Fig. 2. Rapid melting process. Arc over the whole length

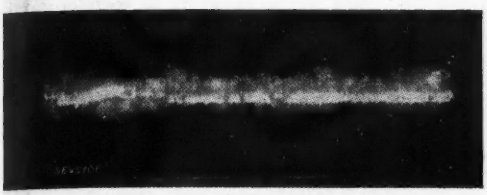


Fig. 3. Vaporization of the fuse wire.

occurs, and in consequence a rapid decrease in the current, producing an excessive voltage, which will become high f the inductance of the circuit is high and the capacity small. Finally the excess voltage pierces the metal vapour column, an arc is formed and the voltage drops suddenly to a small value. The bright band in Fig. 3 is produced by the arc following the breakdown of the vapour column. As the voltage across the arc is relatively small, the rupturing capacity of this type of fuse is limited.

Fuse with gas yielding substances.

In its first form this fuse consisted of a wire stretched across a tube of gas-yielding substance, e.g., fibre, hard rubber, etc. Later these tubes were filled with substances which produce gas under the action of the electric arc, e.g., with chalk powder, borax, etc. If the current is high, excessive voltages may be produced. As a rule, however, the voltage is kept within reasonable limits, since the length of the wire is usually short and the breakdown voltage of the vapour column correspondingly small. The rupturing capacity of the fuse amounts to some ten thousand KVA. The operation of the fuse breaks down with either too small currents, in which case the gas generation is very poor, or with too large currents when, owing to excessive gas generation, the tube bursts.

Fuses with substances which do not yield gas.

In these fuses a substance which does not yield gas, e.g., quartz, sand, oxide or circonium or aluminium, etc., is used as extinguishing medium. The well-known plug fuse which found application only for low voltage circuits belongs to this group, and has been developed recently for applications for high voltages too.

The process of fusing of the wire is practically the same as in the case of the bare wire in open air. The high voltage, mentioned before, occurs at the instant of vaporization of the wire and breaks down the metal vapour column. But the arc burns in the hollow spaces of the surrounding extinguishing medium. Consequently the burning voltage is high, the current does not rise after vaporization, but decreases continuously, and the arc goes out at the next zero passage of the current wave. Since the resistance of the arc is great, the voltage curve at the moment of current rupturing corresponds to that of an a.c. rupturing with predominatingly ohmic resistance.

It can be shown that the vaporization current i_v which is the upper limit of the current is

$$i_v = 155 \cdot q^{2/3} \sqrt[3]{f \cdot I_k}$$

where q is the cross section of the fusible wire in cm², f the frequency, I_k the effective value of the short circuit current, which would be

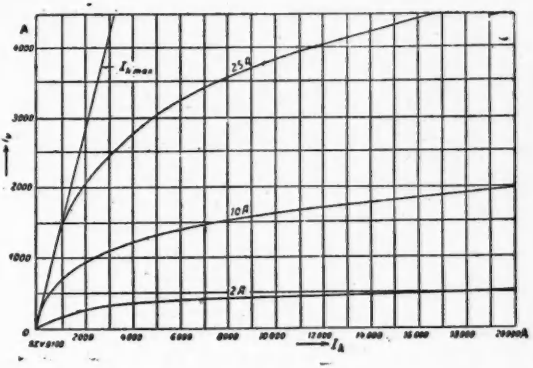


Fig. 4. Relation between the vaporization current i_v and the effective value of the short-circuit current of the network I_k.

reached without fuse in the respective point of the network, C a constant depending on the kind of metal used for the fuse wire. The formula applies only if i_v is small in respect to I_k. From Fig. 4 it can be seen that i_v increases only slightly with increasing output of the network. A 0.2 A fuse wire, for instance, will fuse at about 520 A even if the short circuit output amounts to 300,000 KVA in a 10 kV network. Values obtained from tests are in agreement with theoretical predictions.

The progressively acting fuse.

So far the problem has always been a matter of compromising between the peak voltage and the energy conversion in the fuse. The real aim of the improvement is to reduce both by proper control of the variation of the resistance during the vaporization and arcing process in the fuse. The solution leads to the so-called progressively acting fuses.

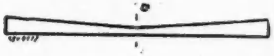


Fig. 5. Fusible conductor of the progressively acting fuse.

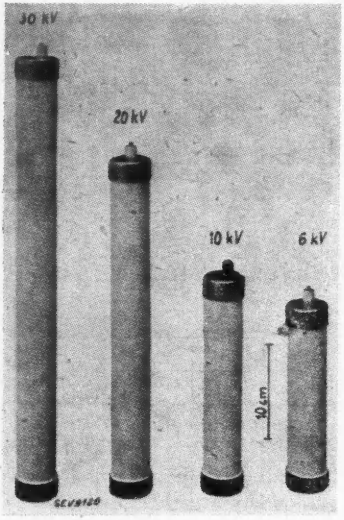


Fig. 6
Progressively acting fuse for 25 A rated current.

It has been shown that the high voltage arises from the simultaneous evaporization of the fuse wire along its entire length. This excessive voltage can be reduced by not allowing the fusible wire to vaporize simultaneously along its whole length, but control it to progress from one point. One comes, therefore, to the fusible conductor shown in Fig. 5. It consists of a thin silver strip which is tapering from the centre towards both ends. The vaporization takes place at the weakest spot " a " at first, and thus the ignition begins only with a short arc. Next the vaporization proceeds along the fusible conductor towards both ends and the arc length increases continuously. Pronounced voltage peaks do not occur any more. A cathode ray oscillogram shows that the voltage peak value does not exceed the crest value of the a.c., and rupturing is practically an ohmic one at zero value of the current. Current and voltage are in phase.

Fig. 7 Progressively acting fuse for 100 A, 15 kV.

In the case of fuses for small currents the construction of fusible strips with uniformly varying cross section becomes difficult. Here the thin fusible wire is alloyed with another metal at individual points, so that the fusing and vaporization temperature is no longer the same on the whole length of the fusible wire. The wire does not fuse spontaneously along the whole length. The arc voltage can be controlled by corresponding dimensioning of the length of the wire or by selecting a proper filler, so that the energy released in the fuse is a minimum. The fuses possess a rupturing capacity of several 100,000 KVA. Since the filler does not give off any gas no appreciable pressure can arise in the fuse.

The dimensions of the fuse up to currents of about 25A are very modest, as can be seen from Fig. 6. The same type of fuse can be used for voltages up to 100,000 V.

A further advance in the construction of fuses for great current strengths is shown in Fig. 7.

RADIATION FROM HIGH-PRESSURE MERCURY LAMPS

By EDWARD B. NOEL. (From *Illuminating Engineering*, Vol. 36, No. 2, February, 1941, pp. 243-56).

FOR the past two years a water-cooled quartz mercury lamp with an operating pressure from 30 to 280 atm. has been available, and at the present time another type of lamp is in the state of development (Fig. 1). The commercial lamp (Fig. 1-A) is the 1000 Watt A-H6, having a quartz bulb, with an inside diameter of 2 mm. and an outside diameter of 6 mm. The arc gap is 25 mm. long. Each end of the bulb is based with a brass ferrule, to provide electrical contact and to ensure proper alignment in the combined water jacket shown in Fig. 1-D. The small experimental lamp, designed for higher brightness and shown in Fig. 1-B, has a bulb with an inside diameter of 1 mm. and an outside diameter of 3 mm., while the gap is 10 mm. The use of the standard water jacket is made possible by an artificial lengthening of the lamp with quartz tubings as shown in Fig. 1-C. Both lamps operate in the horizontal position. They are designated in the following article as 2×6 mm. lamp and as 1×3 mm. lamp.

Spectral Intensities.

Spectral intensities and the mercury pressure

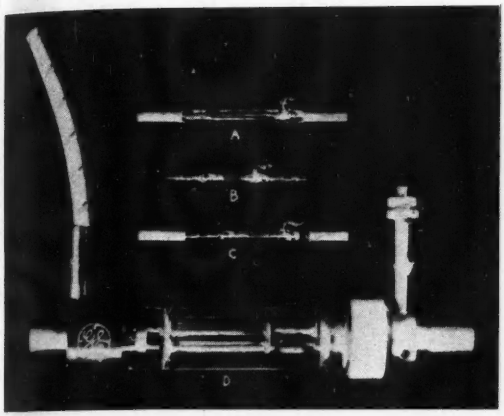


Fig. 1

Lamp and jacket used in obtaining data. A. 2×6× 25 mm. lamp known as A-H6. Normal rating 1000 W.B. 1×3×10 mm. lamp. C. 1×3×10 mm. lamp with extensions and brass base to fit the standard water jackets. D. The jacket used with both lamps.

in the lamps vary with the load. The pressure has been found to be

$$P_{atm} = \frac{\text{Gradient} - 100}{3}$$

where "Gradient" is volts per cm. arc. The formula has been tested up to 150 atm. (550 V/cm.). If this formula holds till 913 V, a voltage, for which spectral intensities have been measured for the 2×6 mm. lamp, the maximum pressure in the tests was 285 atm. The pressure of the 1×3 lamp has not been measured up till now, but is lower for equal gradients.

It has been found that the proportion of the input energy which is radiated in the region between 5400 and 6000 A* decreases slightly with increasing gradient, while the energy between 4600 and 5400 A* and between 6000 and 7000 A* increases almost in direct proportion to the gradient and pressure (Fig. 2). At higher pressures spectral lines characteristic of mercury radiation are no longer sharp, but become broadened, and the spectrum between the lines becomes filled with "back-ground-radiation." Improvement in colour and spectrum can be attained by higher gradients (pressure). The brightness of the arc is a function of the pressure and the power consumption; it increases with the gradient and pressure. But lamps of very considerable brightness operating at moderate pressure have been built by designing for a large power consumption per cm. arc length. A maximum brightness of 90,000 candles/cm² was measured for the 885 V/cm. operation of the 1×3 mm. lamp and 52,000 candles/cm² for 782 V/cm D.C. with 2×6 mm. lamp. Calculations on the 2×6 mm. lamp operated on D.C. give 64,000 candles/cm² for the 953 V/cm. run and 26,000 candles/cm² for the 326 V/cm. run, which corresponds to normal operation.

Since the colour and the brightness of the water cooled mercury arcs improve with increase in gradient, it is desirable to operate them at the highest feasible value. But the life of the lamps decreases rapidly with increasing, temperature and pressure, increasing with the gradient. The useful limit is determined by economic conditions.

The lamps produce a very cool radiation, as

* A=Angstrom Unit.

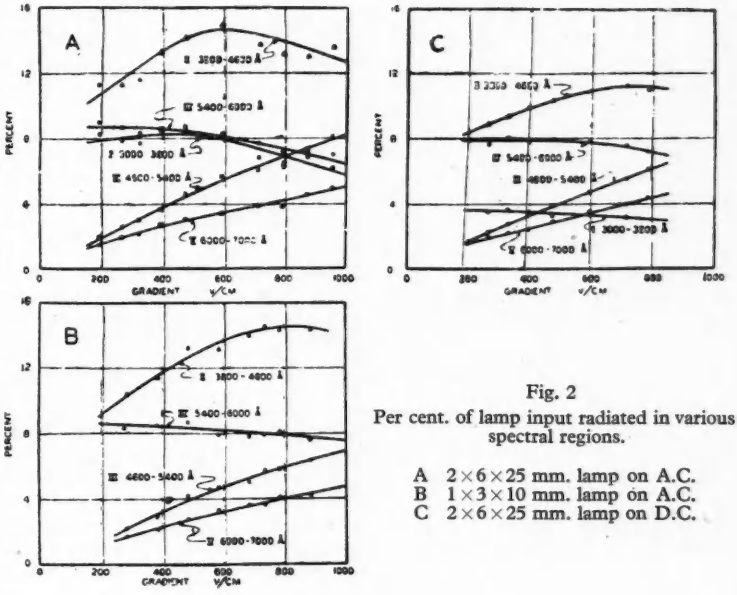


Fig. 2

Per cent. of lamp input radiated in various spectral regions.

A 2×6×25 mm. lamp on A.C.
B 1×3×10 mm. lamp on A.C.
C 2×6×25 mm. lamp on D.C.

can be seen from Table I. The lamp radiates more than twice the light but less than half the energy of the filament lamp of the same input.

TABLE I.

Comparison of energy radiation in the ultra-violet, visible infra-red portion of the spectrum by a 1000 W quartz water-cooled mercury lamp and a 1000 W high efficiency biplane filament projection lamp.

(For the tungsten lamp the figures are for energy radiation beyond the bulb).

	1000 W tungsten lamp	1000 W water-cooled mercury lamp
Ultra-violet 3000—3800A..	1.5 Watt	66 Watt
Visible 3800—7600A ..	150 „	276 „
Infra-red 7600—infin. ..	790 „	71 „
Total Watt radiated ..	941 „	413 „
Lumens	.. 27,500	65,000

Commercial Applications.

The 2×6 mm. lamp A-H6 has an average life of 75 hours. To operate this lamp the supply of suitable running water is essential. It is essential to make certain that the lamp is never turned on unless water is flowing past it, and it is often desirable to have the water and the power turned off automatically in case of accidental breakage, or a failure of the water supply, or of the lamp. This can be achieved by simple apparatus.

The lamp is one of the most efficient sources for the production of long wave ultra-violet and short wave visible radiation, and has found wide application in the photochemical reproduction processes like blue-printing, and direct-printing processes such as Diazotype.

The high brightness is also of value in projection printing directly on to metal, and here it has been found that the steadiness of the light results in sharper half-tone dots and better quality. The high brightness, the actinic quality, and the coolness of the radiation make this lamp suitable for high-power enlarging service. In an enlarger for news picture service it has been possible to make large numbers of successive enlargements on contact-type (chloride) paper with no damage to the negative from heat. When the ratio of enlargement is high, as in the making of photomural, these same qualities are needed in the light source.

Fig. 3

Sally Eilers, Hollywood Motion Picture Star before Television camera at the Schenectady Studio W2XBN.

The chemical industry makes use of these lamps in a few instances where large quantities of ultra-violet are needed for photosynthesis.

In the lighting of television studios, where intensities o 1000-1500 foot-candles are desired, the water-cooled quartz mercury arc makes it possible to reach the high level of illumination required with a minimum of discomfort for the artists. For this service three lamps in a single reflector are used, one lamp in each phase of a three-phase supply, in order to eliminate stroboscopic effects. Schenectady Station W2XBN employs twelve A-H6 lamps in four deep-bowl reflectors (Fig. 3).

The lamps are particularly suited for searchlight service. Greater beam candle-power can be obtained than with tungsten sources. Such searchlights were in use in the New York's World Fair, and some New York buildings employ them for decorative illumination.

MANUFACTURE, PROPERTIES AND APPLICATION OF PLATED STEEL SHEETS

By DR. ING. HANS HOUGARDY. (From *Wekstatt und Betrieb*, Vol. 74, No. 4, April, 1941, pp. 93-96).

THE application of plated sheet metals for chemical plant was made possible by the great progress made in the manufacturing technique of such working materials. The advantages attached to their application is not only a reflection of wartime economy, but is also a direct consequence

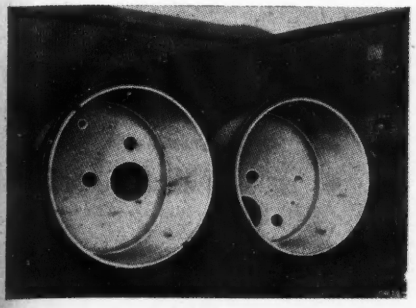


Fig. 1

of their particular properties, which in many respects surpass those of other metals and alloys. Although there are several manufacturing processes known, the rolling-welding process is only of commercial interest in so far as plating of iron and steel sheets is concerned. In the following, therefore, this method only will be considered.

In the rolling-welding process the base and plating sheet metals, prepared for this purpose, are placed one on the other, and after they are brought to rolling temperature are rolled. The thickness of the sheets is proportional to their ratio in the finished composite sheet; the plating usually being 10% of the total sheet thickness. The only precaution to be taken during this operation is to prevent oxidation of the surfaces in contact, which might occur due to rolling at high temperature and the simultaneous deformation. The contacting surfaces of the sheets form an intimately interlocked "welding," and this is further strengthened by a certain amount of diffusion taking place between the two metals. As a result the cohesive force between the base metal and plating film becomes so great that even the severest deformations will not produce separation. As an example Fig. 1 shows a welded tank made of plated steel, fabricated by pressure. The sheets did not exhibit any tendency to separate after such severe treatment, and therefore, from a mechanical-physical point of view the result is a "homogenous" material; chemically, however, it can be looked upon as iron with one side rendered corrosion and acid resistant due to the protective plating. The machinability of iron is not adversely affected by this process.

In Germany welding is used exlusively for jointing plated sheets. In the U.S.A. riveting is frequently employed. Table I. gives some general rules for welding which are self-explanatory. The following additional points should be considered.

Copper plated sheets up to 1.0 mm. plating thickness are welded in the same way as pure copper sheets. Gas welding is preferable; electro-welding may be used for sheets of greater thickness. In this case Lessel type of tube electrodes should be used, the higher voltage being supplied by two series connected rectifiers.

Nickel plated sheets are usually electro-welded, and rapid-welding is essential to prevent the absorption of iron by the seam. It is recommended to split up the welding into two stages; a thin layer is welded first on the plating side, using a thin electrode, and then a second layer is welded on top of the first.

Steel plated sheets (plating metal consisting of an acid and corrosion resistant steel) are welded in a single layer at both sides, and the welding alloy should be, for both sides, of a composition suitable for welding the plated side. The finished seam must be properly cleaned.

V, U or X-seam welding is used depending on the sheet thickness being less than 10 mm., more than 10 mm., or whether plating is on both sides respectively. After the welding is finished on the iron side of the sheet, which is the usual routine, the oxidised metal and beading should be removed from root of seam before starting to weld from the plated side. A grinding wheel or a chisel can be used for this purpose, and is an important precaution if high quality welding is to be expected.

A condition of successful welding is that the plating thickness should not be less than 0.6 mm. Therefore, it will become necessary to modify the plating thickness in some cases, and if strength considerations allow it, with sheets over 20 mm. thickness the plating may eventually be less than 10% of the total thickness.

Cutting of plated sheets with gas flame is a simple operation. With copper and nickel plating, the flame is applied at the plated side and should make an angle of about 10-15° with the normal to the plate. In the case of steel plating this is modified to 12-14°. In the latter case it is imperative to keep the oxygen pressure high (about 6 to 8 atm.) otherwise the plating metal, which becomes pasty under the action of the flame, will flow together behind the flame. The high oxygen pressure prevents this by blowing the molten metal clear of the cut.

Flanges for jointing cylindrical parts are prepared in either of two ways according to the wall thickness. If this is less than 10 mm. the ends of the cylinder are pressed over to form a rim of

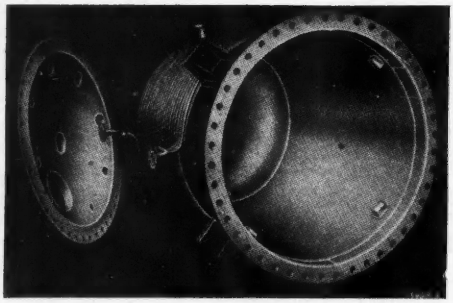


Fig. 2

double thickness over which the flange is fixed. As can be seen from Fig. 2, the plating sides of the two parts are thus lying on each other. With greater sheet thickness the flanges are separately plated.

Finally, plated sheets allow new technical features to be introduced in chemical plant. For example, it is an excellent material from which to construct boilers heated by electrical induction. A primary winding, well insulated from the boiler produces eddy currents in the iron part of the boiler shell which dissipate their energy as heat. The plating steel containing 18% Cr. and 8% Ni. is non-magnetic and therefore inhibits the formation of the heating eddy currents. Many difficulties which might arise from other systems as, for instance, when the heating coil is fixed inside the boiler, are overcome in this fashion. It also provides an excellent means for temperature regulation.

Table I.

Principle Rule: Weld first iron side, then plating side.

Type of Plating	Side	Gas Welding	Electro-Welding
Copper Plating	Iron	Iron wire	Iron electrode
	Plating	Copper wire & flux. Neutral flame. Hot hammering of seam.	Lessel type tubular electrode. Use two series connected rectifiers.
Nickel Plating	Iron	Iron wire	Iron electrode
	Plating	Nickel wire & flux. Neutral flame. First with thin wire, then with heavier wire.	Nickel electrode, possibly rapid welding. Use two series connected rectifiers.
Steel Plating	Iron	Iron wire Better: austenitic Cr-Ni wire, at least in the first layer.	Iron electrode Better: austenitic Cr-Ni electrode, at least in the first layer.
	Plating	Austenitic Cr.-Ni wire. Neutral flame. Brush and clean seam.	Austenitic Cr.-Ni electrode. Clean seam.

DETERMINATION OF "DOUBLING" OF SHEET METAL

By WERNER JELLINGHAUS. (From *Technische Mitteilungen Krupp, Forschungs-Berichte*, 1941, pp. 31/36).

"DOUBLING" defects occur in rolled sheet metal when reduction in thickness is excessive, and the metal ruptures, leaving small sub-surface cavities, are filled by gases or slag; they are of course of extremely small dimensions. Since the slag or gas has a smaller electric conductivity than steel, doubling can be detected by measuring the resistance of the plate. For this purpose the resistance of the plate is measured between points forming a net on the sheet surface.

The schematic arrangement of the instrument used is shown in Fig. 1. It is made up of two symmetrical parts, each comprising electrodes (5 and 6) to carry the current, an auxiliary electrode (9 and 10), and an electromagnet (11 and 12) to hold the electrodes on to the plate (7). In addition a source of electricity (D.C. or A.C. with a dry rectifier), an ammeter (A), a resistance (3) and a voltmeter (4) are contained in the instrument. A special shock protector (not shown in figure) protects the voltmeter when placing it on the plate or during removal. The current density is about 10 A. and the voltage varies between 0.2 and 0.3 mV, according to plate thickness and amount of doubling in the sheet.

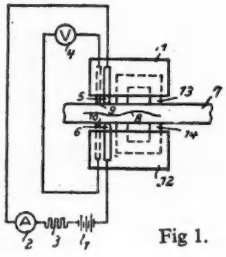


Fig 1.

Fig. 2 is an illustration of the result of testing a sheet plate. The figures at the measuring points refer to voltmeter deflections (one division $=2\times10^{-5}$ V). Doubling in the plate surface is indicated by the increase of the voltmeter deflection. If the plate surface is covered with scale it should be cleaned by grinding to obtain accurate results, as the scale is not uniform over the whole surface.

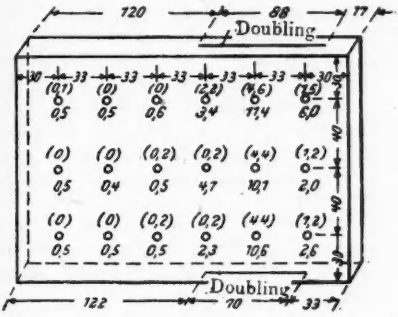


Fig. 2. Example of measurement by means of the doubling-tester. Dimension in mm. Values in brackets = Measuring points scaled. Values not in brackets = Measuring points ground.

As a further example, Fig. 3 shows results of measurements on an " over-rolled " plate. Along the edge of over-rolling the deflection of the voltmeter increases from about 1 to 10-15.

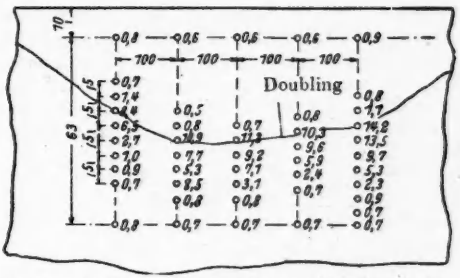


Fig. 3. Example of an " over-rolling." Distance of the measuring points 5 mm., starting always from the doubling.

With very thick plates the diameter of doubling might become less or equal to the plate thickness. In this case measurements become unreliable, since the transverse resistance might approach very nearly that of the sound part of the plate.

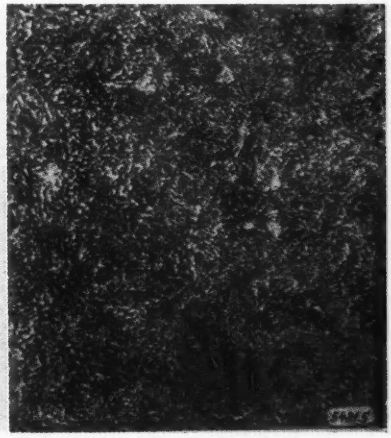
Finally the instrument can also be used to determine binding-defects of plated sheets.

A NEW TEMPERING MEDIUM

By E. Damm. (From *Werkstatt und Betrieb*, Vol. 74, No. 7, pp. 176-177).

It is a well-known fact that steels tempered in water are more liable to buckling than steel alloys which can be quenched in milder mediums, such as oil. During the past few years a new practice has been developed, namely, to perform the tempering operation in steps by plunging the article into water at 200°C and then allowing the article to cool in air at 20° C. This method is only applicable to steel alloys because of the slow rate of cooling. During tempering in water steam is formed, and this effectively blankets parts of the article, and in consequence such spots remain soft after tempering and buckling is still uncontrolled.

The new type of tempering bath, described below, can be used equally well for pure steel and for steel alloys, and at the same time the tendency to buckle is reduced if not entirely eliminated. This tempering medium can be prepared from the known tempering salts used for heat treatment. The salts, containing saltpetre, are dissolved in a small amount of water, so that the



specific gravity is about 1.5, and for tempering at least 1.7 to 1.8. If the work is treated in this bath at 20° to 130° C, any desired hardness can be obtained, and the result should be satisfactory from the point of view of eliminating buckling.

A series of experiments was carried out on steels St 50.11, St 60.11, St 70.11, St C 35.61, St C 45.61, and St C 60.61. The experiments were also extended to machine parts and gear wheels of blister steel St C 10 and St C 16.61. In each case the result was excellent, and in addition, the bath could be regulated so as to give a pre-determined Rockwell hardness.

As an example a shaft 400 mm. long, 16-20 mm. diameter, made of St C 10.61 and St C 16-61 hardened to 1 mm. depth, when treated in cold water showed buckling of about 1.5 mm. eccentricity. The same figure for an identical shaft, when treated in the new quenching medium, was only 0.1 mm., the hardness being 65 Rc.

Figs. 1 and 2 show a section in the blister zone with both types of tempering medium.

This new method of tempering enables the manufacturers to use steel in place of steel alloys, which can be thus utilized for more important applications.

MECHANICAL SPOT AND FINISH SCRAPING

By Dr. Weingarten. (From *Das Industrieblatt*, Vol. 46, No. 19, 6th July, 1941, pp. 964/965).

For the proper working of a scraping machine it must be provided with a tool holding device which allows movement of the scraper along a straight line, and in addition the length and speed of the working stroke must be adjustable. With regard to the nature of the work, it is imperative to suppress all vibration of the scraper. These conditions can be fulfilled by adopting a special support in which the tool can be brought to any required position and the working stroke can be adjusted by an operating handle. The machine is particularly suitable for scraping medium and large type surfaces. Not only iron, but cast steel, steel, and light alloys can be finished by the machine. Pig iron of the highest Brinell hardness can be readily scraped by the machine when using a widia tipped scraper. This provides a convenient method of truing machine tool, slides and tables, the surfaces of which become brittle by long service.

The machine is arranged on a tripod pillar (1) with a handle (21) for moving the stand. The joint (3) of the support (4) can be raised or lowered by means of the ring (5) along the column (2). This way the support can be adjusted so that the spindle (7) of the tool holder (6) lies parallel to the working plane. The support (4) holds the telescopic shaft (8) to which the tool holder is connected; (11) is the scraper fixed to the spindle (7). The inclination of the scraper can be adjusted by a clamping device (12). The shaft (8) can be fixed to the support (4) by a slight pressure upon the lever (9). When machine is

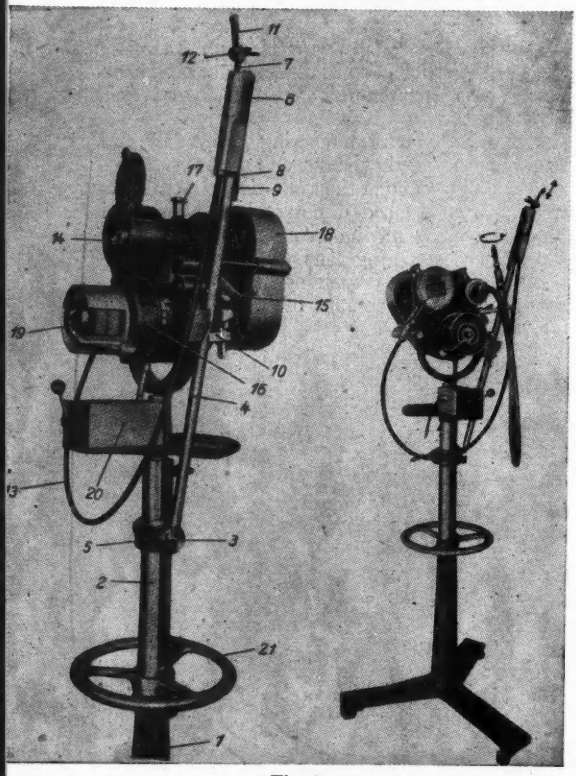


Fig. 1

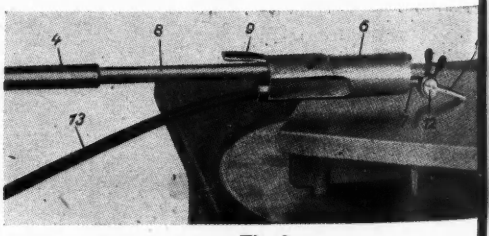


Fig. 2

not in use the catch (10) holds the support. The piston performing the reciprocating motion is driven by a cable (13). The stroke can be adjusted between 3 and 24 mm. and is governed by a gear (14). The operation of the brake (15) will bring the machine quickly to rest. The machine is driven by a motor through a V-belt, and the speed of the machine is adjustable by means of stepped pulleys; (18) is a guard to protect the pulleys, and (19) an attachment for grinding and lapping blunted scrapers; (20) is the starter of the machine.

THE EFFECT OF AUXILIARY HEATING SURFACES ON HEAT LOSSES IN BOILER PLANTS

By ING. H. WINTER. (From *Die Wärme*, Vol. 64, No. 15, April, 1941, pp. 163-165).

MODERN steam generator plants are invariably provided with air pre-heaters and feed water economisers. The dimensions of these auxiliary heating surfaces diminish the heat losses in the exhaust gases, and in the following a quantitative analysis of this problem is described, as carried out on an existing plant.

Temperature Conditions.

The investigation was carried out on a moving grate Wagner-Bauer type of boiler. Temperature measurements were first made for various values of the excess air, the boiler output being adjusted in each case to full load. From these readings, taken throughout the boiler plant, the variations of the exhaust gas temperature could be ascertained.

Referring to Fig. 1, it can be seen that by increasing the excess air the exhaust gas temperature at the end of the furnace (T_F) is decreasing; it is still decreasing, though to a lesser extent, before the superheater (T_1), and is increasing after the superheater (T_2). After the economiser the temperature increase is more rapid (T_3). In other words, up to this phase the increase in the excess air reduces the cooling of the exhaust gas due to its greater specific heat. The curves showing the gas temperature before the air heater (T_4) and on leaving the plant (T_a) indicate that an increase of the excess air is accompanied by a more marked cooling of the gas in the air pre-heater. This becomes obvious if the fact is considered that simultaneously with the increase of the specific heat of the exhaust gas, the water equivalent of the admitted air is also increased due to the greater air quantities. Furthermore, the heat transfer in the superheater is improved by the great velocity of the gas flow.

Considering now the heat losses (V_a) in the exhaust gases, it is obvious that these increase more rapidly than is expected by the rise in tem-

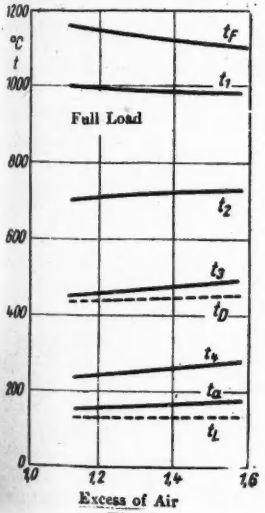


Fig. 1

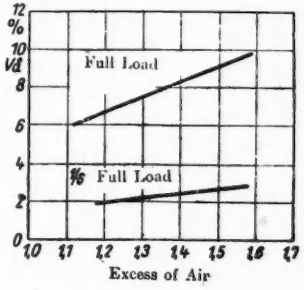


Fig. 2

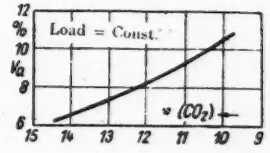


Fig. 3

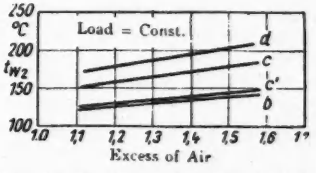


Fig. 4

Fig. 1. Exhaust gas temperatures, steam and air temperature as function of excess air of combustion.

Fig. 2. Losses in exhaust gas in dependence of excess air, at full load and at partial load.

Fig. 3. Heat losses in exhaust gases in dependence of CO_2 content affected by the excess of air.

Fig. 4. Temperature of water when leaving feed water pre-heater, in dependence of excess of air.

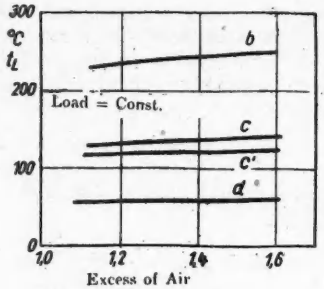


Fig. 5. Variation of Air temperature with excess of air.

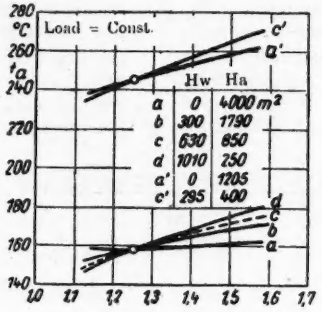


Fig. 6. Influence of ratio: Feed water/air heating surface upon the exhaust gas temperature.

Fig. 7. Influence of above ratio upon the heat losses in the exhaust gases.

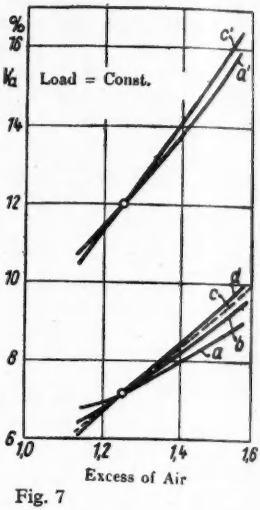


Fig. 7

perature, since apart from this temperature rise the quantity of the exhaust gas leaving the boiler is increased. From Fig. 2, a 10% increase of excess air (at full load) causes an 0.85% additional heat loss. On the other hand, the excess air should not be kept too low, otherwise incomplete combustion takes place and the CO content in the exhaust gases will increase. As an example, at 25% excess air, a CO content of 0.2 (by volume) will correspond to 1% reduction in the boiler efficiency. The CO_2 content, alone, is not a true indication of the boiler efficiency, since the boiler was found to work at the same efficiency when the CO_2 content was 13.3% and the CO content was zero, as when the CO_2 was 14.5% and the CO 0.2%.

In Fig. 3 the heat loss (V_a) was replotted as a function of the CO_2 content. This curve shows that 1% change of CO_2 content does not correspond to a constant change of heat loss, but is greater with decreasing CO_2 content.

Influence of the Auxiliary Heating Surfaces.

For the sake of investigation the auxiliary heating surfaces were modified so that for various ratios of the feed water/air heating surface, the heat loss (V_a) was 7.12% when the excess air was adjusted to 25%. The curves a, b, c and d were obtained in this fashion and are shown in Figs. 4 to 7. The curves a' and c' were similarly obtained, but in this instance the heat loss was 12% with 25% excess air. The numerical values of the heating surfaces for both the feed water economiser and air preheater, are tabulated in Fig. 6.

In Figs. 4 and 5, the feed water and air temperatures are plotted against the excess air. It can be seen from Fig. 5 that the air temperature is hardly affected by the changes in the excess air. Therefore, the air pre-heater has a steadying effect on the heat losses, and it can be seen from Fig. 6 that the greater the air heating surface/feed water heating surface ratio, the less is the rise of the temperature and consequently the less the heat losses with increasing excess air.

From the consideration of the curves a' and c' it becomes clear that when the steadying effect of the increase of the above mentioned ratio is smaller, the greater are the normal heat losses in the boiler (see Fig. 6). This is due to the fact that with greater heat losses, only a limited air preheating surface can be employed. Another conclusion that can be drawn from Fig. 7 is that if the normal heat losses in the exhaust gas are great, these are more markedly affected by the increase of the excess air.

RARE GAS FILLED, PUMPLESS MERCURY VAPOUR RECTIFIER, TYPE SECHERON

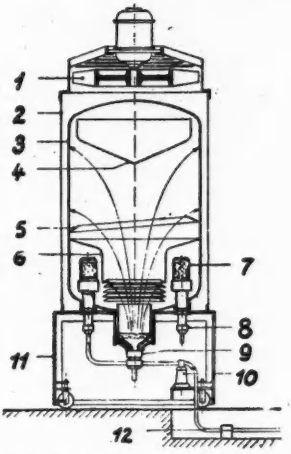
(From *Schweizerische Bauzeitung*, Vol. 117, No. 16, April 19th, 1941, pp. 185-186.

THE first model of a Sécheron type mercury vapour rectifier has been in commission for the last year and a half at a tramway station, working at 600 V., and has rectified not less than 400,000 A./hr. during this period without failure. The cross section of a Sécheron rectifier is

Fig. 1

Hg-Rectifier type Sécheron.

(1) Fan and Motor
(2) Cover for Air Circulation
(3) Steel Container
(4) Gas Chamber
(5) Groove for Hg.
(6) Anode Shield
(7) Anode and Grid
(8) Connection for Anode
(9) Connection for Cathode
(10) Insulated support
(11) Earthed stand
(12) Anode and Cathode cables.



shown in Fig. 1. A welded steel container is surrounded by an earthed casing. Cooling air circulates between the casing and the steel container, driven by a fan which together with a small motor is mounted on top of the casing. Since liquid cooling has been dispensed with no failure resulting from corrosion can occur.

The connections to the electrodes is by means of fused high quality insulation material with metallic caps. These caps are fixed to the insulator by means of a very thin layer of glass, which is able to withstand very high temperatures. Consequently much higher pressures and temperatures may exist in the rectifier than in other designs. All the electrodes are arranged at the bottom of the container, and since the anode is closely located to the kathode the voltage drop across the arc is very small, sometimes not more than 20 volts.

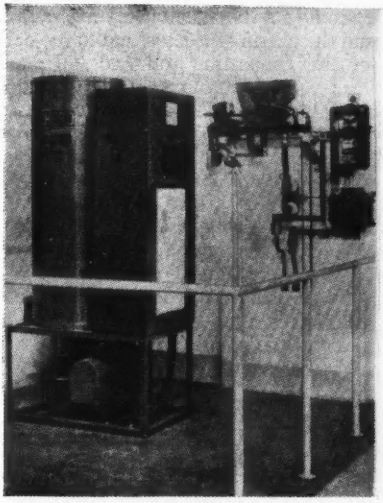


Fig. 2

To eliminate dangerous high frequency voltages when the rectifier is cold, it is filled with rare gas. The gas is evenly distributed in the whole volume when cold, but is forced up into a gas chamber by the mercury vapours when the rectifier is loaded. Hence, the arc is surrounded by pure mercury vapour. The presence of the rare gases in the rectifier enables easy starting even at 0° C., and the rectifier can be switched on full load, overload or even to short circuit without danger of damaging the set. This solution also obviates the use of an overload safety device. The rectifier is especially suitable for continuous operation.

ENGINE STRESSING CAUSED BY "KNOCKING"

By Dr. Jos. Geiger. (From *ATZ, Automobiltechnische Zeitschrift*, Vol.44, No. 13, July, 1941, pp. 327-335).

Since the phenomenon of knocking in petrol engines causes severe stressing in the driving mechanism as well as in the cylinder head, endeavours have been made to find a measure of the amount of overstressing caused in this fashion. The theories put forward suggested a relationship between the stresses and the peak value of the gas pressure, or the time rate of increase of pressure, dp/dt; others have attempted to correlate the stressing with the second differential coefficient d^2p/dt^2 of the gas pressure. In this article it will be shown that none of these theories hold good, but that the maximum stresses in the engine depend both on the peak value of the gas pressure and the ratio of the natural frequency of pressure variation to the natural frequency of the driving mechanism or entablature respectively.

The initial consideration in the investigation of the problem is the evaluation of the natural frequency of the driving mechanism. As this is of several parts, its elasticity will be the integral elasticity of the individual parts. In particular, consideration must be given to the

compression of the piston and connecting rod, to the bending of the shaft and crank pin, the crank web and the bearing bushing, and to the deformation of the connecting rod ends. In addition there are the oil cushions in the bearings, the distortion of which will contribute to the total deformation (compression) of the driving mechanism.

To obviate the elaborate strain measurements of all these parts, which would still not give accurate results owing to the small strains involved and the complicated nature of the deformations, the compression of the system was determined by applying a pressure to the piston head and measuring the total reduction in length. Fig. 1 shows the result (the kink in the graph is due to the behaviour of the oil cushions).

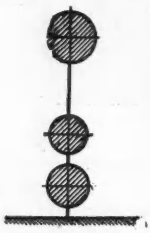


Fig. 2

For simplicity of calculation, the mass was considered to be concentrated at three points, as shown in Fig. 2. Now the natural frequency of the system can be determined, and it was found to be about 40,000/m. for a light design with aluminium piston. In practice this figure is modified to about 30-40,000/m. owing to the co-vibration of the crank shaft and big end of the connecting rod.

To proceed with our original problem, reference is made to a previous article of the author's (ATZ 1937, page 614) in which the gas pressure after ignition was considered to alter in one of the following ways.

1. Sudden increase of pressure (Fig. 3)
2. Uniform increase and decrease of pressure (Fig. 4)
3. Sinusoidal pressure rise (Fig. 5)
4. Pressure wave is of cosine wave form (Fig. 6).

Since the case of a continuous sinusoidal pressure rise was purposely omitted, the damping effect of the engine need not be considered.

Finally for simplicity of calculation, it was assumed that there is no pressure acting on the piston prior to zero time. Actually the gas pressure is increasing uniformly during the compression stroke, but this does alter the results, only by complicating the solution of the problem.

Bearing these assumptions in mind, the force acting upon the pistons is given by

$$x = \frac{P}{c\left[1 - \frac{\omega^2}{\omega e^2}\right]}\left[\sin \omega t - \frac{\omega}{\omega e}\sin \omega e\, t\right]$$

where (x) is the force on the piston, P is the maximum gas pressure, c is the stiffness of the driving mechanism in kg/unit compression $\omega = \frac{n\pi}{30}$ with n= frequency of gas pressure variation, $\omega e = \frac{n_e \pi}{30}$ with n_e=natural frequency of the driving mechanism, and it is the time in secs.

Fig. 7 shows values of (x) for three different values of $f = n/n_e$. It should be noted that although the values of (f) are remote from resonance (f=1), the force on the piston is considerably higher than the maximum gas pressure.

The analysis of Fig. 8 is most instructive. In this illustration the maximum force acting upon the piston is plotted against f for the four cases of pressure rise as shown in Figs. 3 to 6. It can be seen that the force exceeds that of the maximum gas pressure in each case, and the peak values do not occur at resonance, but at lower values of f.

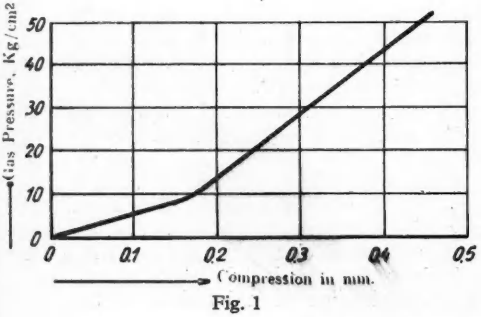


Fig. 1

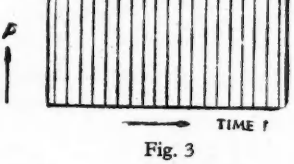


Fig. 3

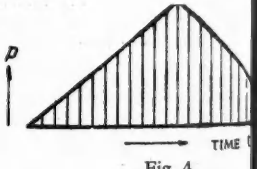


Fig. 4

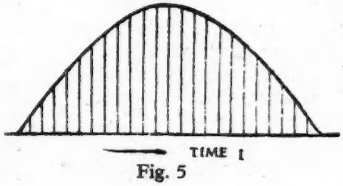


Fig. 5

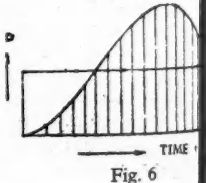


Fig. 6

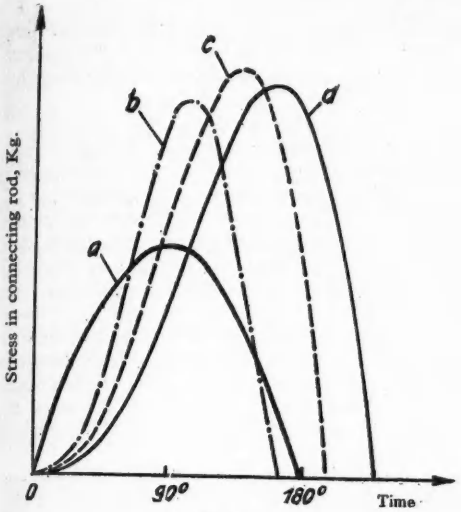


Fig. 7

Considering the relationship between p, dp/dt, d^2p/dt^2 and the force acting upon the piston respectively, it is clear that p cannot be a measure of the maximum force, since the latter is invariably higher than the gas pressure. The test for dp/dt fails too, because considering the case of sudden pressure rise, the maximum force (curve D) does not become infinite as would be expected. Also if the pressure rise is a sine or cosine wave, the peak value of the force in the latter case (curve B) is not half of that corresponding to a sinusoidal wave (curve A). Lastly from curve C it follows, that d^2p/dt^2 cannot be correlated to the maximum force on the piston, since the second differential coefficient of the pressure becomes infinite at the vertex of the triangle (Fig. 4), and curve C should correspondingly reach a very high value.

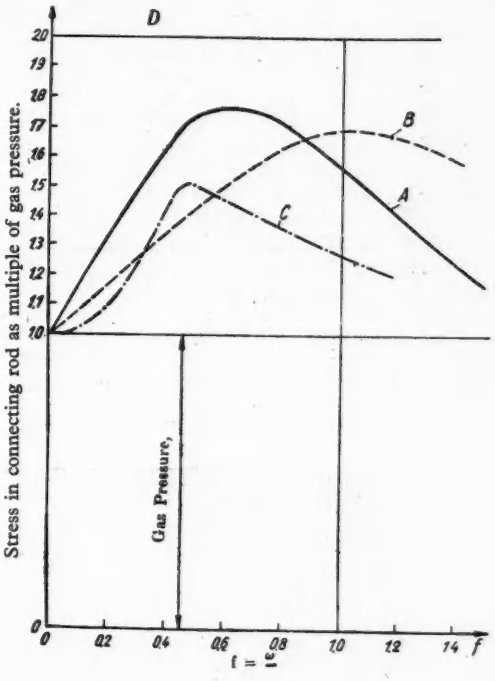


Fig. 8

From the foregoing consideration it can be seen that the stresses in the driving mechanism will depend initially on the peak value of the gas pressure, secondly upon the ratio $f=n/n_e$; if f lies between 0.4 and 1.2 the stresses will be increased by about 90% compared with those caused by the gas pressure. The natural frequency of the gas pressure rise can be determined if diagrams, such as shown in Fig. 9, are available; these were taken from a "knocking" engine. Also, as in Fig. 11, a pressure diagram from a knocking engine, the frequency can be readily determined if the rising portion of the pressure wave is considered to be half a sine wave. Generally the frequency of the gas pressure rise is very much higher than the natural frequency of the driving system; as an

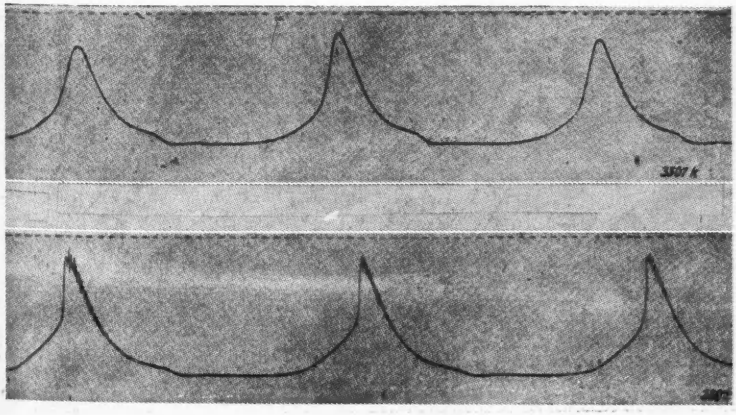


Fig. 9

Fig. 10

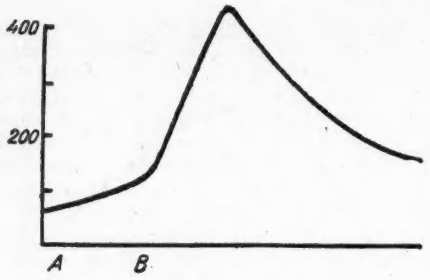


Fig. 11

example, the frequency corresponding to Fig. 9 was found to be 327,000/m. In this case f becomes 8.2 and the overstressing of the driving mechanism is negligible.

Obviously if a continuous sinusoidal pressure oscillation occurs, the peak value of the force acting upon the piston will occur at resonance, and its value will depend upon the damping effect in the system.

Stresses in the Engine Block.

Generally speaking the same principles apply to the engine block as to the driving mechanism; the gas pressure is transmitted through the cylinder cover to the block. Although the system of masses have a much greater stiffness, it does not necessarily follow that the natural frequency is much higher as the masses concerned are larger.

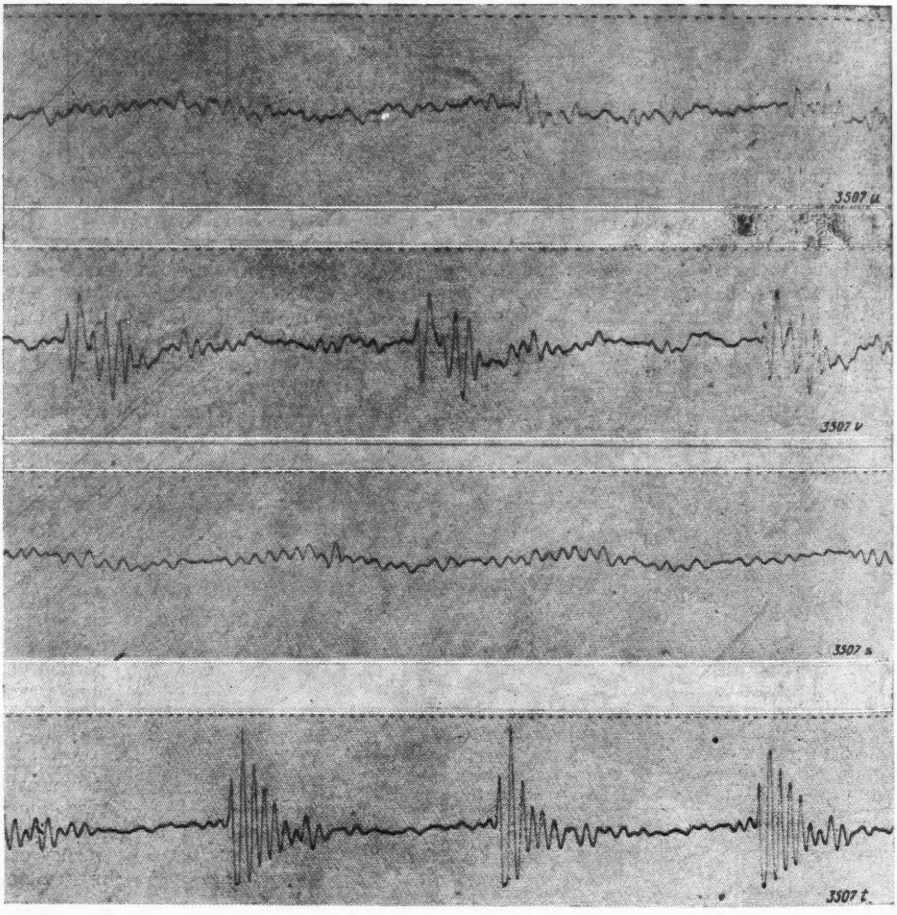
There are two sets of oscillations produced in the cylinder cover and block, one in the direction of the piston movement, the other perpendicular to the cylinder axis. Figs. 12 to 15 show the striking difference between normal and knocking

Fig. 12

Fig. 13

Fig. 14

Fig. 15



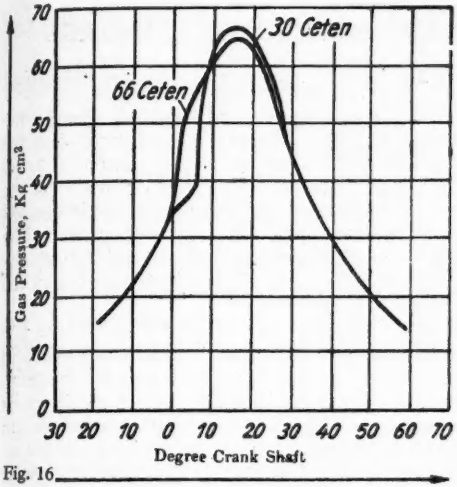
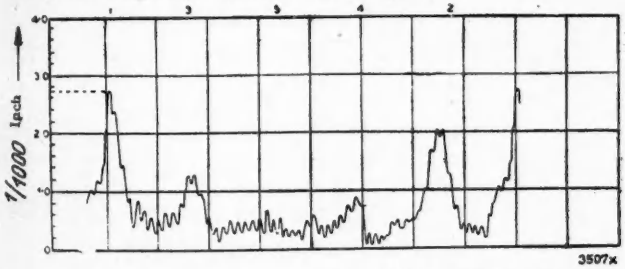


Fig. 16.

operation of the engine. While the maximum acceleration during normal operation is only about 35 to 40 m/sec (Fig. 12), during knocking this is increased to 465 m/sec. Vibration in the transverse directions is smaller and reaches about 75 m/sec. That these vibrations are not caused by the mass acceleration of the piston is clear from the fact that their frequency is about 56,000/m, and remains constant when the engine speed is increased. Calculations, too, put the natural frequency of the block to about 56,000/m.

Referring now to Fig. 11, by considering the rising portion of the pressure curve to be sinusoidal, the frequency becomes about 17,000/m.



and f becomes 0.304. This corresponds to an increase of about 26% in the resulting pressure upon the block as can be seen from Fig. 8, curve A. The same result is obtained if the pressure curve is considered to be part of a cosine wave. In other words, the stress in the cylinder block is considerably larger than that corresponding to the pressure peak, even at normal operation.

Finally some measurements were made on a five cylinder four stroke engine, using a Sunbury indicator. The pressure curves for the two kinds of fuel used are shown in Fig. 16. The extension diagrams of the engine casing are shown in Figs. 17 and 18. The natural frequency of the engine block was calculated and found to be about 27,000/m. The extensions when the engine was running on 30 C fuel were about 33% larger than when using 66 C fuel. The frequency of the pressure rise for both fuels was determined from Fig. 16, and was estimated to be 4100/m and 13,900/m for the 66 C and 30 C fuel respectively. Therefore f becomes 0.143 and 0.435 for the two fuels, and this corresponds to an increase in the pressure acting upon the block of 22% and 74% respectively. Slightly higher values were obtained from actual measurements, but this was most probably due to the discrepancy between sinusoidal and actual wave form of the pressure rise.

Possibility of Resonance.

As stated before, dangerous forces might be produced in both the driving mechanism and cylinder block at resonance. In practice, however, resonance between the gas pressure rise and the driving mechanism is unlikely to occur, since a pressure rise occurs only once a revolution, the frequency therefore being about 1000/m. There is consequently ample time for the vibrations in the driving mechanism to be damped out between the two pressure waves.

The engine block presents a different problem. Oscillations are set up in it by every cylinder and therefore the frequency of pressure wave increases with increasing number of cylinders. Consequently with higher speeds, the ratio f may become fairly small. It is advisable, therefore, to place the cylinders with consecutive firing order as far apart as possible. The actual stresses occurring in the engine naturally cannot be predicted, as there is insufficient data available to estimate the damping factor.

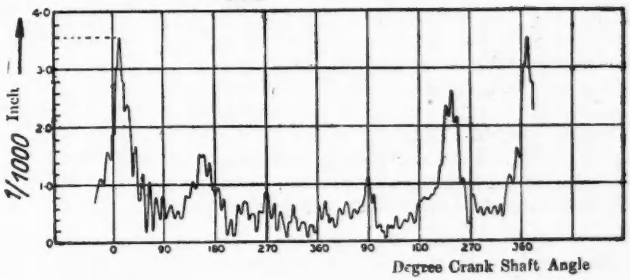


Fig. 17 (left). Fig. 18 (right)

MODERN STEEL AND REINFORCED CONCRETE HANGARS

By Dr. Ing. Alfred Mehmel. (From *Zeitschrift des VDI*, Vol. 85, March 6th, 1941, pp. 290-294).

In general only circular polygonal or rectangular sheds are constructed. When designing a hangar the first demand of the layout is its utilisation. This is the proportion of the sum of the rectangles defined by span and length of the aeroplanes to the total hangar floor area, $\eta = \frac{\Sigma F_F}{F_H}$. The higher this figure the better the utilisation of the hangar. Fig. 1 shows a hexagonal layout for the protection of six aeroplanes. A smaller type of aeroplane would reduce the utilisation from 91% to 70% and bigger types could not be sheltered at all. Such considerations lead to the demand that the utilisation should be satisfactory for various types of aeroplanes.

We have seen that the larger the hangar the better and less difficult its utilisation, but the greater the fire losses. This reflection limits the size of a hangar to 4000 m² floor area. As the hangar should offer to the pilot a minimum obstacle, it should be built as low as possible. The height of the roof structure is determined by span and load. The door is usually in one of the larger walls.

Steel Construction.

The demand for a low construction leads to the use of the plate-webbed frame construction. Such a rivetted frame with a span of 75 m. is shown in Fig. 4. The lower construction balances the higher costs of the plate webb construction. The design of the main girders as frame work is advantageous since the construction is made more rigid in this way.

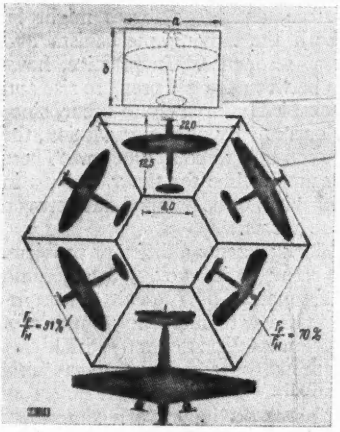


Fig. 1

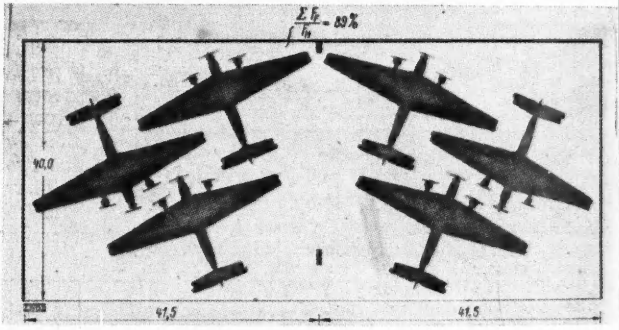


Fig. 2

Figs. 2 and 3 show two plans for sheltering six aeroplanes of the Junkers 52 type. The hall construction shown in Fig. 2 has a support for the roof in the middle of the front door, dimensions are 83 × 40 m., and the utilisation $\eta = 0.89$. The hangar shown in Fig. 3 has no support for the roof, the dimensions 73 × 41 m. and $\eta = 1.1$, or 24% better than the layout shown in Fig. 2. The increase of the span results in an increase of the price per square unit but the floor is more valuable. Besides the surface of the roof, the floor space, surrounding walls and the heating are reduced in cost. Taking all that into account the layout 3 is cheaper than that of 2.

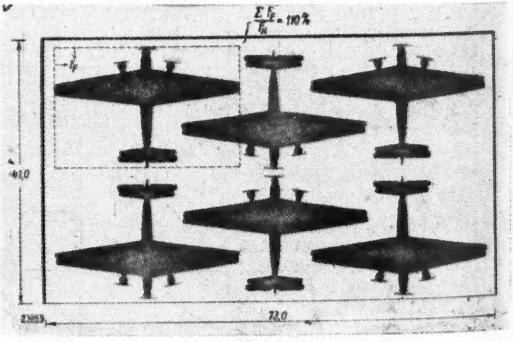


Fig. 3

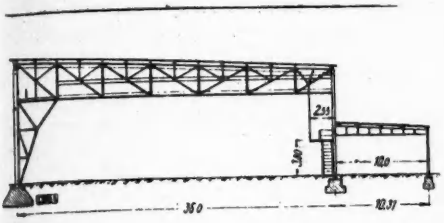


Fig. 4

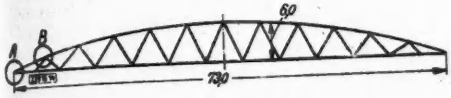


Fig. 5

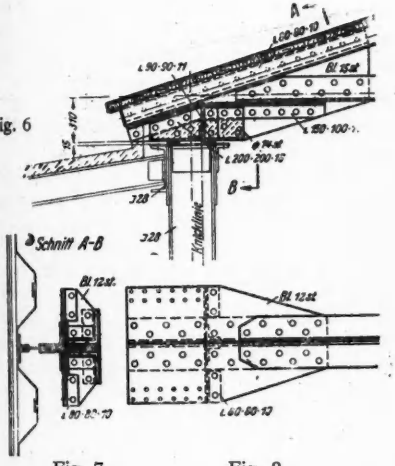


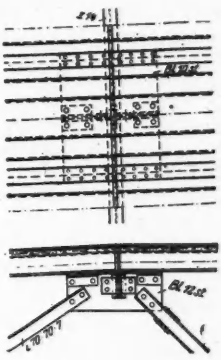
Fig. 6

Fig. 7 Fig. 8

A similar idea of "space closing" structure can be found in the corrugated double arc of Figs. 5 to 8. The rigidity of the arc is so great by the double corrugations that diagonal bars are not required.

Reinforced Concrete Construction.

Reinforced concrete hangars up to 50 m. span are built with frame construction with tie rods (Fig. 9), or else the structure is supported on



Figs. 9 and 10

girders on two supports (Fig. 10). The concrete is specially treated by keeping it wet for about 6 weeks with spraying. The load is only gradually transferred to the main reinforced concrete supports by retaining the auxiliary supports for about the same period. This method reduces shrinkage and creepage of the concrete.

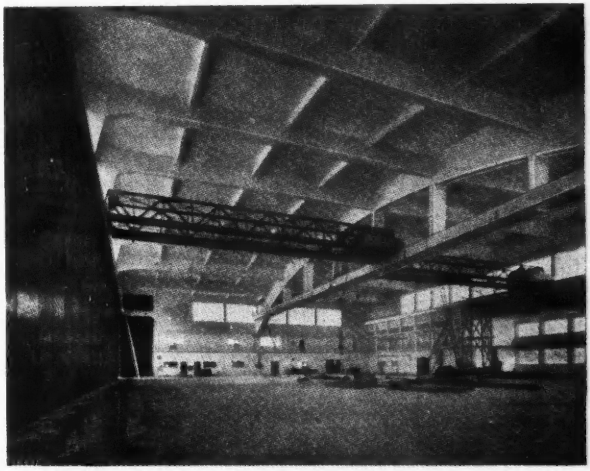


Fig. 11

It was possible to keep constructions half a year after dismantling of the poling bars completely free from cracks.

The main girders of reinforced concrete hangars of large span are designed in an arch form. Fig. 11 shows a hangar of 100 m. span, where the shearing force is taken up by tie bars.

X-RAY EXAMINATION OF WELDED SEAMS

By E. BRANDENBERGER. (From *Schweizer Archiv*, Vol. 7, No. 2, February, 1941, pp. 54-56).

THE chief object of welding is to produce a faultless and homogeneous joint between the welded parts. Welding is followed by an examination of the seam to evaluate the efficiency of welding, and to detect faults that might have occurred in the welding as a result of various factors.

A most valuable method is given by X-Ray examination of the welded seam, since in this way the welding is not disturbed. All the faults which are lying in the path of the projected X-Ray become visible, irrespective of their position along the cross-section of the welding. The limitation of the perfectness of this method is that only macroscopic faults lying in the path of the X-Ray can be detected, and therefore a negative result of the examination is not conclusive.

The faults in welding may be classified in two groups, according to the nature of their appearance.

(a). Faults recurring periodically, or which constitute a systematic fault owing to the regularity or multitude of their appearance. Several factors might be responsible for these, such as unsuitable working current, dimensions of the electrodes, type of flux used, insufficient preparation of the work, and finally unskilled labour.

(b) Faults belonging to the second group might be termed incidental faults ; and this group comprises all defects in welding which might be caused by a temporary breakdown of apparatus, or indisposition of the otherwise skilled labourer.

The more practical problem is the detection and selection of those faults which will notably affect the quality of the welding and will in consequence adversely affect its strength characteristics. Two general conclusions can be drawn, however, from practical experiences. Detection and effect on welding efficiency do not follow parallel lines, in other words, no group of faults can be detected as having a greater influence on the strength of the welding. The other conclusion is that sporadic porous spots and slag inclusions are generally of no importance in the quality of the weld. Fractures, as a result of fatigue tests, did not occur near these defects in a regular manner.

A full range X-Ray examination, i.e., one which covers the whole weld, will obviously bring out all the macroscopic faults, and those which escape detection, owing to their minute size, will most probably have no influence on the efficiency of the weld. Cracks which might escape detection are considered later.

X-Ray examination may also take the form of a sampling inspection ; in this case the examination is limited to some selected points only. The efficacy of this simplified examination depends on the representative points chosen. Good practice is to select these points so as to cover the work of all workmen and every type of weld. With this precaution it can be safely assumed that systematic faults will not escape detection, and appropriate attention will be drawn to the presence of incidental faults. If the welding, by this method of examination, proves unsatisfactory, it may be followed up by a full X-Ray examination.

The following example gives an instructive comparison between the two types of X-Ray examination. 28 welded seams of 5 to 10 m. length were examined by both these methods, the welding including first class and inferior seams. The sampling test was made at intervals of 1.5 mm. and as a result, in 15 instances, the two methods gave the same result. Sampling examination revealed the systematic faults and proportionally the same number of incidental faults. In the remaining 13 instances the sampling test resulted in a more favourable examination than the full X-Ray inspection. The difference, however, was not considerable, and the faults revealed by the full inspection only were not detrimental to the weld. Summarising, 26 instances out of 28 gave closely agreeing results with either type of X-Ray inspection.

In two instances the gross error involved in the sampling method was the omission of the detection of cracks. To do justice, however, it should be mentioned that cracks were not always detected by the full examination. As an example, 3 tests were carried out on weldings known to contain cracks, and the full X-Ray examination failed to reveal this defect in two instances. Therefore, it may be stated that X-Ray examination is not conclusive regarding crack detection, and therefore such microscopic defects may escape detection altogether.

On the basis of the previous considerations, it can be said :

(a) Full X-Ray examination, apart from some special cases, is not essential ; sampling examination will give satisfactory results, provided certain precautions are taken.

(b) Sampling examination will give the workman the same confidence in his work as full examination. All systematic faults will be detected, and, to a certain extent, the incidental faults.

(c) With careful preparation of the work, the systematic faults (which are the important ones) can be eliminated completely, and the incidental faults can be reduced to a minimum. Cracks in the welding require some further consideration, and it is advisable to follow the X-Ray inspection with a metallurgical examination.

WORKING EXPERIENCES WITH EXPULSION PROTECTIVE GAPS IN A NETWORK WITH EARTH-COILS (PETERSEN COILS)

By KURT WESCHE, Frankfurt. (From *Elektrizitätswirtschaft*, Vol. 40, No. 8, March 15th, 1941, p. 132/5).

THE 15 kV network, which is situated in the Mark Brandenburg, has a length of 3,500 km and feeds 1253 built-in transformer stations and 73 pole transformers. In 400 to 600 stations, interruptions had been caused in each lightning season by blowing of one or several fuses. The more the insulation of the overhead lines had been reinforced during the last years, the more disturbances occurred in the small transformer stations. The lightning arresters used generally in Germany could not be installed in these small stations for economical reasons. Reasonable protective devices appeared however in the deion gaps and the expulsion protective gaps used in America. There prevailed, however, the opinion, that this type of spark gap would only work in systems with earthed central point. Nevertheless, the excess voltage tube for 15 kV shown in Fig. 1 has been developed in 1936 and its suitability in compensated systems, even in cases of a single phase ground has been proved subsequently.

Till spring, 1937, 20 transformer stations had been equipped with these gaps. During summer, 1937, 19 discharges, some of them with currents up to 4,300 A had been registered by magnetic links. Since then all 1253 transformer stations have been equipped with the new protective device and its excellent performance could be proved statistically.

The cost of the equipment of one station amounts to RM. 45.—or £2 approximately (RM. 5. for the 3 gaps, RM. 20. for the parts for fixing (Fig. 2) and RM. 20. for erecting cost). Table 1 shows the decrease of the number of disturbances during the last few years. There were more thunderstorms in 1937 and 1939 than in 1938 and 1940. During the first three years all stations with protective gaps, over which storms had passed, were inspected, in order to see if the gaps had worked satisfactorily or if, in spite of the presence of the gaps, damage had occurred. The number of discharges over gaps grew approximately proportionally to the number of gaps installed. Of course there were more discharges than actually stated during these three years. 56% of all discharges passed over all three gaps of one station simultaneously. The 4,421 gaps have worked in 1886 cases, as far as it could be proved. Only in 60 cases had damage occurred in stations equipped with gaps, that is in 3.2% of all registered discharges.

Table 2 gives a summary of the failures which occurred in stations equipped with the new device. During 1940 only 1.4% of the stations have been damaged.

(re 1) This kind of flash-over occurred on bushes with a porcelain insulation of 17 cm. or less. It was known that these bushes were the weakest points of the stations and they will be replaced by and by. 5 cases of damage were caused by a wrong adjustment of the gaps, which has been corrected according to the results of experiments to 50 mm. for the inner and 18 mm. for the outer gap.

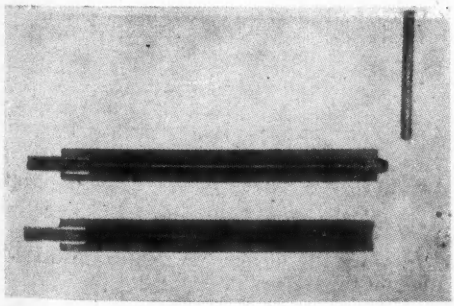


Fig. 1. Expulsion protective gap for 15 kV cut.

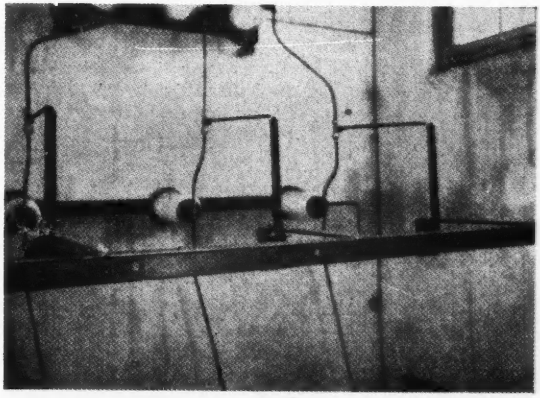


Fig. 2.
Expulsion protective gap installed in a Transformer Station.

(re 2) Flash-over on insulators standardised for 15 and 20 kV. The lightning stroke had occurred within a few hundred yards from the station. This kind of failure had decreased, as all insulators which showed defects caused by former discharges have been replaced lately. Furthermore, all stations which are exposed to dust are cleaned twice a year. For the cleaning of the live insulators a special brush is used, which is fixed on a long tube of bakelized hard paper.

(re 3) The bushes R20 have a short arc over distance over the porcelain surface and get dirty very quickly. Replacing began several years ago.

(re 5) A great deal of damage (40%) in protected stations occurred in the transformers. Neither loss of oil nor ageing of the insulation was the cause. Old transformers were not damaged more frequently than new ones. The age of damaged transformers was

Less than 1 year	..	With 3 transformers
1 to 5 years	..	With 3 transformers
6 to 10 years	..	With 6 transformers
11 to 15 years	..	With 4 transformers
16 to 25 years	..	With 4 transformers

(re 6) As from 3,759 tubes only 2 became defective in 1940 (and this probably on account of bad workmanship, recognized, when the gaps were inspected afterwards) the reliability of the device can be regarded as sufficient, especially in comparison with the function of other lightning arresters.

It seems that the gaps are able to discharge about 4,000 A, as such currents have been measured by the magnetic links placed near the common earthing conductor. No damage has been caused by short-circuit currents in stations with 3,000 A short-circuit current.

(re 7) The arc over between phases occurred over a distance of 19 cm. In two cases it has been found that the lightning discharge had occurred at a distance of 1.5 km approximately. The potential difference between the two upper conductors of the line seems to have surpassed 150 kV. It discharged on the first point with a distance of 19 cm. over air on a three-phase isolator. Further research will be made to clear up this phenomenon.

TABLE I.

Improvement of the working safety of transformer stations by the installation of expulsion protective gaps.

	1937	1938	1939	1940
Number of thunderstorms	520	345	475	342
Number of high tension fuses blown during thunderstorms	525	248	64 (20)	36 (10)
Number of transformers damaged by excess voltages during thunderstorms and replaced at once	41	27	18 (7)	9 (6)
Meters damaged by thunderstorms	60	37	33 (26)	14 (14)
Number of stations equipped with gaps	20	315	1000	1253
Number of discharges stated by the gaps	19	250	1017	600
Cases of damage in stations with gaps	1	8	33	18
Cases of damage in stations with gaps in %	5.0	2.5	3.3	1.4

The figures in brackets give the number of cases of damage in stations equipped with gaps.

TABLE II.

Sources of damage in stations equipped with gaps	**Number of cases of damage**			
	1937	1938	1939	1940
(1) Flash over on transformer bushings type 15 or smaller	—	7	6	2
(2) Flash over on insulators type 15 and 20	—	—	6	1
(3) Flash over on bushings without rain shed type 20	—	—	1	1
(4) Flash over on bushes to the flange	—	1	4	2
(5) Cases of damage inside transformers	1	—	13	7
(6) Cases of damage on protective gaps	—	—	3	2
(7) Arc over between two phases	—	—	—	3
Total	1	8	33	18

10 TON TRAVELLING CRANE OF ALUMINIUM WITH A SPAN OF 27.4 m.

By O. STOCKMAR. (From *Aluminium*, Vol. 22, 1940, p. 470/73, Abstract from the *Zeitschrift des V D I*, Vol. 85, No. 10, March 8th, 1941, p. 243).

FOR the aircraft shed of a new aerodrome the instalment of 10 ton travelling cranes was provided. In regard to the construction of the roof comprising an overhung construction with a projection of 40 m., only a crane with a very low weight of the bridge could be used. Therefore, an Aluminium-

Manganese-Silicium alloy was chosen as material for the bridge. The strength of this alloy, named "Pantal," when hardened approaches that of commercial steel. By arranging the winding gear and the control apparatus on the side of the supporting structure, which was attached to the supports of the roof, the overhung girders were released from the greater part of the weight of the travelling cranes. The maximum load on the outer crane way consists only of the useful load and the smaller part of the net weight of the crane bridge.

Each crane consists of two main lattice girders and two secondary girders of the same construction. The main girders have a height of 2.2 m. The upper beam of the main girder consists of two U profiles 200/85/10/14 mm., the lower one of the two angle profiles 90/90/10 mm. Junction plates are used for the assembling of the members of the lattice work. The crane rail is made out of steel because of the high wheel pressure. The travelling wheels of the crane bridge and of the cable travelling crab are made out of steel too. The crane bridge without its carriage has a weight of 6 ton. The deflexion due to the maximum load of 10 ton and the rope pull has been measured as being 20 mm., that is 1/1400 of the span of the crane, and does, therefore, not exceed the permissible limit. As the material is very resistant to chemical actions, the construction has not been provided with a protective coating.

THE USE OF FLUORESCENT MATERIALS FOR LIGHTING PURPOSES

By WERNER A. SEELIG, Berlin. (From *Elektrotechnischer Anzeiger*, Vol. 58, No. 7, April 2nd, 1941, p. 206/10).

THE use of ultra-violet radiation of electric discharge lamps began with the tubular advertising lamps, the radiation of which was supported by a coating of the inner surface of the tube with a fluorescent material.

Fluorescent materials have been used up to now in two different ways. The one is in connection with air-raid protection, the other one brought the design of new types of lamps suitable for the illumination of workshops, offices and other rooms.

The use of fluorescent materials under black-out conditions.

It has long been known that HgQ-and HgL-lamps with bulbs not absorbing the ultra-violet radiation can be used to render certain materials fluorescent. The scales of measuring instruments of the switch-boards of power stations were marked with fluorescent materials and were rendered luminescent by ultra-violet radiation. This kind of illumination had the advantage of the absence of any glare.

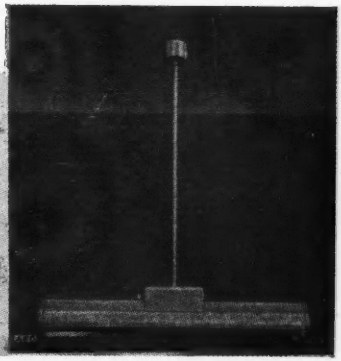
At the end of 1939 new fluorescent materials were introduced, which fluoresce only as long as they are influenced by ultra-violet radiation. As these chemicals could be produced at lower costs than those obtainable before, a large field of use was opened, especially in ameliorating the traffic during black-out time. Many installations were made according to the following principle. In the street or on the place, where fluorescent signs had to be used, one or several lamps with a broad radiation were installed, containing a source of ultra-violet light. Fig. 1 shows a type of these lamps manufactured by the AEG. For the bulb of these lamps violet coloured glass is used, which absorbs the visible light as far as possible.

(*To be continued*)

Fig. 1

Fig. 2

Fig. 3. Low tension fluorescent lamp.



stripped water

In the preparation of tobacco for good quality cigarettes, the centre stem is stripped from the leaf in the manner shown above, but if this process is not carried out, tobacco including the centre stalk is uneven and contains dust which irritates the throat of the smoker. Similarly with the water required for feeding into water tube boilers it is necessary to strip from it the soluble salts and other impurities in order to secure a non-scaling, non-corrosive feed water. The Permutit "Deminrolit" Process produces a perfect stripped water from any supply without the use of heat or steam.

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